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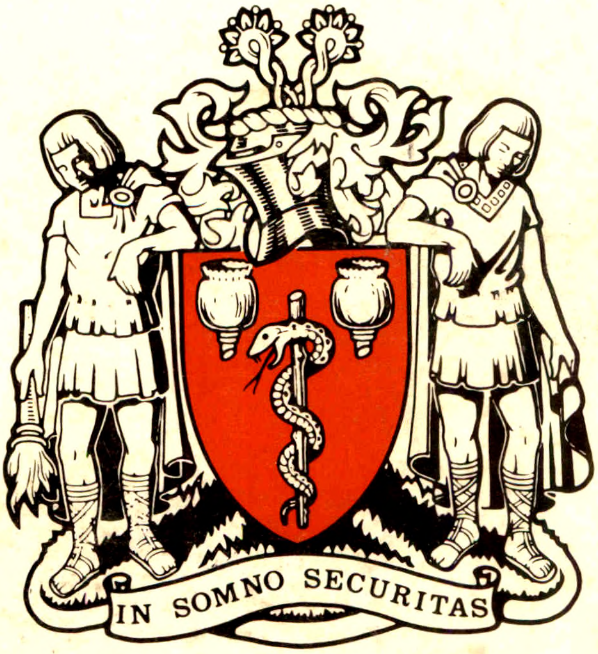

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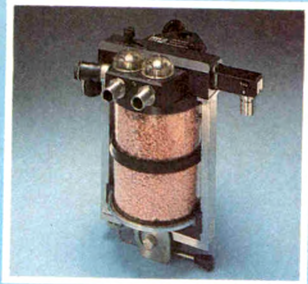

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Vol . 45

Anaesthesia

Journal of the Association of Anaesthetists of Great Britain and Ireland

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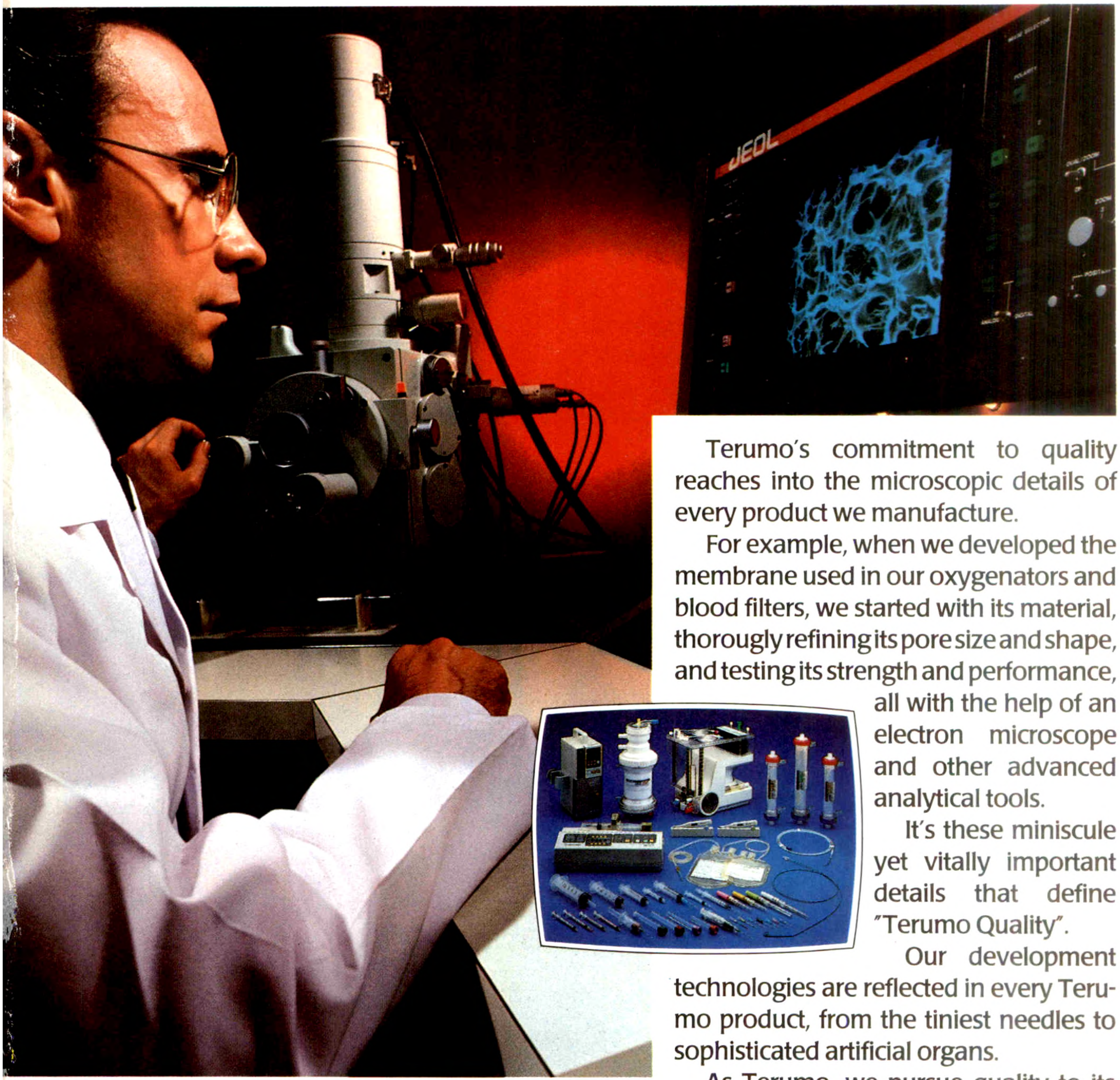

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Anaesthesia, 1990, Volume 45, pages 1–2

Editorial

Change of clinical practice

The occasion of the Annual Scientific Meeting of the Association of Anaesthetists of Great Britain and Ireland at Swansea in 1989 was marked by the inclusion of a session wherein editorial representatives of three different journals presented five papers published in the last year which, in their opinion, should change clinical practice. The writer argued that whilst some editors of general medical journals campaign covertly, as is editorial wont, others did so quite openly. The need for campaigning in *specialist* journals is less apparent since it is presumed that all authors seek to influence their readers by what they write.

It seems reasonable at the beginning of the year to remind some readers of my choices, the reasons for them, and to use the opportunity of my annual editorial to place these views on record. An anaesthetist may be a doctor who cares, a technocrat who invents, a clinician who treats, a scientist who experiments and (or) a citizen who evaluates. Each anaesthetist may be described in one or more of these terms (and there may be other descriptions). My choices were based on the belief that these functional or behavioural characteristics of anaesthetists would be represented in the audience and that therefore each of my choices should interest someone.

Fluid deprivation before surgery is common clinical practice. The effect of a small drink on risk factors (gastric volume more than 25 ml and pH less than 2.5) for pulmonary aspiration was examined before[1] and Agarwal and colleagues[2] did so again. Repetition is a proper activity for clinical investigators in order not only to confirm early findings but also in the attempt to avoid fraud. Furthermore, it is clear that the previous attempts to encourage a more benign approach to a small drink had failed, since the practice of fluid deprivation is still widespread, at least in this country. The poignancy of this paper was that the study was undertaken in a country (India) in which eight or more hours without any fluid would not be widely appreciated by anyone as pleasant! The authors confirmed that a small drink of water (150 ml) reduced the volume of stomach contents, raised its pH and diminished the sensation of thirst to a statistically significant extent. The use of morphine and promethazine as premedicants did not alter this effect. Patients, apart possibly from children, do not often complain about this particular routine but perhaps, if they were given the opportunity to do so, they might. If larger studies confirm that a small drink (in the absence of contraindications) is harmless, patients might appreciate the improved comfort provided by this humane gesture and our practice would change.

It is still relatively early days for the oesophageal detector device (my example for the technocrat) which was first displayed as a poster at a World Congress of Anaesthesiology by Junius and Pollard[3] and reported here by Wee in 1988.[4] The substitution of Ellick's evacuator suggested by Nunn[5] was investigated for reliability[6] and found to be surprisingly satisfactory. If our practice could be changed so that this device were used always, and particularly when tracheal intubation appears easy in fit young patients, then the rare unrecognised and disastrous oesophageal intubation would become rarer still. Note that the oesophageal detector device is not recommended for difficult tracheal intubations but it is likely to be effective when overconfidence would otherwise permit error.

The recent debate about the routine use of anaesthetic induction rooms was brought into focus by the perceived need for separate monitoring devices located both there and in the operating room. The capital costs gave excuse to some, pause to others, and constituted a challenge to be met by others. Anaesthetists who travel overseas have noted that anaesthesiologists in other countries do not always seem to require separate rooms: perhaps these visiting anaesthetists ignore the presence of suites of operating rooms with more than double the number of rooms that exist in hospitals in the United Kingdom. Soni and Thomas[7] carried out an investigation to answer the apparently simple question, 'Are patients more anxious if they are admitted direct to the operating room than if they go to an anaesthetic room for their induction?' They, using limited measurements, found no difference. The study may need to be repeated with more rigorous tests of anxiety and with equally anxious patients 2 or 3 days before operation in each group. If it were possible to reduce the use of induction rooms in some operating suites there could be substantial capital savings, but this change in practice may take a long time.

A notable reduction in the incidence of critical incidents was achieved in one hospital (from 1 in 160 to 1 in 353) by means of three changes.[8] Improved discussion about mistakes within the department, the replacement of old anaesthetic machines and the widespread publicity given to a formal checklist (and its assumed use) were claimed to be responsible. It would obviously have improved the study were only one variable changed at a time: nonetheless the problems seemed so frequent that a three-pronged attack was certainly justifiable. The Association of Anaesthetists of Great Britain and Ireland has recently devised a new checklist and this is now for consultation through the Linkman organisation. The list breaks new ground because the tests advocated depend on the presence of an in-line oxygen analyser; the latter device is already part of the recommendation for minimal monitoring which the Association has published.[9] The Survey of Anaesthetic Practice reported that no test of the anaesthetic machine was done in 21% of cases. The introduction and use of such a test would represent a change of practice of those anaesthetists and would also reduce the risks of life threatening events in patients.

My last choice was of an Editorial and a Special Article which were the two published of a series of three items (one is yet to be published) about the need for anaesthetists to practise, in a caring fashion, as doctors. Counselling is neither a skill inherited because of alle-

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giance to a particular medical discipline nor is it possessed by virtue of increasing age: it is a skill which needs to be learnt. Mulrooney[10] and Bacon[11] had to counsel the relatives of patients who had suffered from rare and serious events and ones with which, by definition, few anaesthetists have to deal frequently. They suggested that preparation followed by a cautious, sympathetic and truthful approach are likely to be effective despite the emotional turmoil which is an inevitable part of these occurrences.

If the lessons which all these writers expound are read and understood our practice will be changed, and in my view, for the better.

J.N. LUNN
Editor

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Editorial notices

Anaesthesia News

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Manuscripts must be submitted in accordance with the internationally recognised *Uniform requirements for manuscripts submitted to biochemical journals* (*British Medical Journal* 1979: **1:** 432 5). Details will be found in the Notice to Contributors to *Anaesthesia* at the end of this issue.

Anaesthesia, 1990, Volume 45, pages 3–6

Accidents, near accidents and complications during anaesthesia

A retrospective analysis of a 10-year period in a teaching hospital

V. CHOPRA, J. G. BOVILL AND J. SPIERDIJK

Summary

A retrospective analysis is presented of all reports of faults, accidents, near accidents and complications associated with anaesthesia in one hospital from 1978 to 1987. 113 074 anaesthetics were administered in that period, of which 97 496 were for noncardiac procedures. There were 148 reports; 39 were of dental damage. Peri-operative cardiac arrests during noncardiac surgery were reported 29 times. Sixteen of these were fatal. Anaesthesia was thought to have played an important role in 13 cardiac arrests (1 per 7500 anaesthetics) and six were not successfully resuscitated (1 per 16 250 anaesthetics). There were 12 reports of postoperative peripheral neuropathies (1 per 9422 anaesthetics). Failure to check, lack of vigilance and inattention or carelessness were the most frequently associated factors with the rest of the reports.

Key words

Complications; accidents, cardiac arrest.
Statistics; mortality rates.

The risk of death attributable to anaesthesia has decreased from 1 in 2680[1] to 1 in 10 000[2] in the period from 1954 to 1982. Zeitlin,[3] reported a possible 13-fold decrease in death rate related to general anaesthesia in the period 1977–84 as compared to the period 1955–64. However, in the recent report of a confidential enquiry into peri-operative deaths,[4] only 3 deaths in 555 258 anaesthetics were solely because of anaesthesia (an incidence of 1 death in 185 056 anaesthetics). Anaesthesia, while associated with low mortality in recent years, is still associated with a significant morbidity.[5] Human error is an important factor in the causation of anaesthesia-related faults, near accidents and accidents.[6,7] The methods used to gather information about the safety of anaesthesia and to establish the risk of mortality, morbidity and complications have included anecdotal tales, in-hospital audit and peer reviews, reports to medical defence societies, retrospective studies, reviews of specific problems and prospective studies. We present here a retrospective analysis of reports of anaesthesia-related accidents, near accidents, faults and complications during a 10-year period in one hospital.

Methods and results

In 1976, a Faults, Accidents and Near Accidents (FONA) Committee was established in the University Hospital Leiden. The task of this Committee is to collect and analyse reported faults, accidents, near accidents and complications that relate to patient care in the hospital. Medical and nursing staff are required to report all occurrences to the Committee. Patients also have the right to report directly to the FONA Committee. These definitions are used by the Committee.

Fault. A procedure, which has resulted (or could have resulted) in injury or harm to a patient, while this injury or harm (or chance thereof) could have been prevented by another procedure.

Accident. Any event, except a fault or a complication, which has resulted in harm or injury to a patient.

Near accident. An event, which could have developed into a fault, a complication or an accident, but which was prevented from so developing either by chance or by a previously unplanned intervention.

Complication. Harm or injury to a patient occurring as a result of a known risk of a treatment or a diagnostic procedure.

We have analysed all the records of reports made to the FONA Committee by the Department of Anaesthesiology, during the 10-year period from 1978 to 1987. In that period 113 074 anaesthetics were administered, of which 97 496 were for noncardiac surgery. There were 148 reports to the FONA Committee. A breakdown of these reports according to categories is shown in Table 1. The largest single group is that of dental damage, followed by peri-operative cardiac arrests. The total incidence of cardiac arrests associated with noncardiac surgery was 1 in 3362.

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Table 1. An analysis of reports to the Faults, Accidents and Near Accidents (FONA) Committee.

Category	Number
Dental damage	39
Cardiac arrests (with fatal outcome)	18
Cardiac arrests (successfully resuscitated)	11
Wrong drug administration	8
Wrong dose	6
Wrong blood administration	2
Skin burns	5
Peripheral neuropathies	12
Hypotension and bradycardia	7
Miscellaneous	40
Total	148

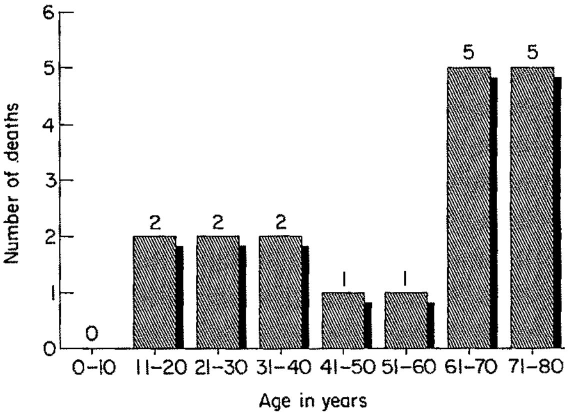

Fig. 2. Fatal cardiac arrests in relation to the age groups.

Eighteen of the 29 (62%) cardiac arrests had a fatal outcome, giving an incidence of 1 death per 5417 anaesthetics for noncardiac surgery. Anaesthesia was thought to have played a role in the causation of cardiac arrests in 13 patients (1 in 7500). Six of these 13 patients could not be successfully resuscitated (1 in 16 250).

The majority of deaths associated with anaesthesia (61%) involved patients with an ASA classification 4 and 5 (Fig. 1). Ten of the 18 deaths (55%) were in patients older than 60 years of age (Fig. 2). None of the patients with an ASA classification 4 and 5, who developed cardiac arrests could be successfully resuscitated (Fig. 3). Details of patients within an ASA classification 1–3 who developed cardiac arrests in the peri-operative period, are summarised in Table 2. There was thought to be a preventable cause for the cardiac arrest in 8 of these 17 patients. Errors in drug administration and hypoxia were the most commonly associated preventable factors.

There were 14 reports of faults in drug administration (Table 3) and two reports of administration of wrong blood. Twenty-one of 39 reports of dental damage involved either patients with carious teeth or those who presented with a difficult intubation. Of the rest, one was an emergency intubation, one a patient with faciomaxillary fracture and in 16, no clear cause was identifiable. These 16 reports were made by patients directly to the Committee. No record of dental damage was made on the anaesthetic charts. All of the five reports of skin burns except one were caused by a faulty diathermy plate. One incident was caused by the use of 'cold' light source of a bronchoscope for transillumination of the radial artery during arterial cannulation in a child.

There were 12 reports of peripheral nerve injuries, an incidence of 1 per 9422 anaesthetics. Seven of these involved the ulnar nerve; two the brachial plexus; one each, the radial and the median nerves; and one was cauda equina syndrome that occurred after a spinal block. Eight of these 12 nerve injuries were caused by an incorrect position of the patient during anaesthesia.

Forty other reports were grouped together as miscellaneous. Fourteen of these were classified as complications while the rest were faults, accidents or near accidents. The factors associated with these are summarised in Table 4.

Discussion

This study, like all retrospective studies, suffers from limitations. The reports on which our findings are based are not necessarily a fully accurate representation of what occurred. There may have been failure to record significant events at the time of their occurrence. The possibility of bias within the reports cannot be excluded since these were not made anonymously. It is probable in this study that most serious mishaps were reported, but not all minor incidents. It is also possible that some deaths were not reported because they were thought to be as a result of the

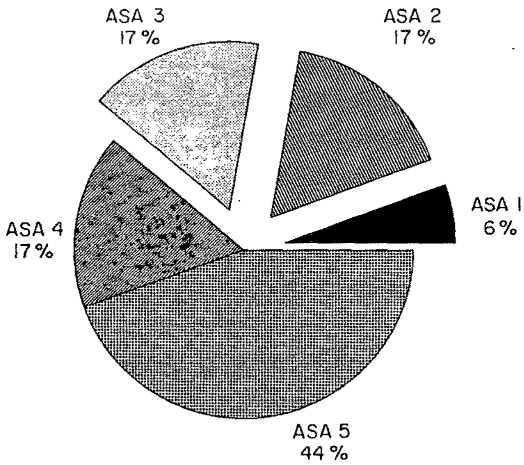

Fig. 1. Fatal cardiac arrests in relation to the physical status of patients.

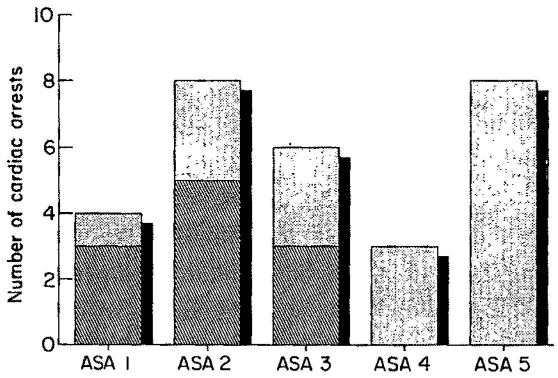

Fig. 3. Peri-operative cardiac arrests in relation to the physical status of patients. Hatched areas represent successful resuscitations.

Table 2. Summary of cardiac arrests in patients with an ASA classification 1–3.

Age (years)	ASA status	Fatal outcome	Description
2	1	No	Cardiorespiratory arrest after caudal block. Intravenous injection of bupivacaine.
4	3	No	Hyperkalaemia after intravenous suxamethonium in a child with rhabdomyosarcoma.
26*	2	No	Overdose of halothane due to unintentionally open vaporizer.
34	1	No	Anaphylactic shock due to hypersensitivity to intra-uterine dextran during hysteroscopy under general anaesthesia.
38	1	No	Surgical bleeding and hypotension during pneumonectomy.
48	3	Yes	Hypoxia as a result of difficult tracheal intubation because of anatomical malformation. Later tracheostomy (pre-induction tracheostomy was indicated).
54*	2	No	Overdose of neurolept anaesthesia leading to postoperative respiratory arrest in the recovery room.
54*	2	No	Hypotension leading to cardiac arrest during epidural anaesthesia.
57*	2	No	Hypoxia due to accidental bronchial intubation.
58*	3	No	Hyperkalaemia because of rapid intravenous injection of potassium chloride during general anaesthesia.
59	2	Yes	In the recovery room, after adbominal surgery. Autopsy revealed myocardial infarction.
68	2	Yes	High epidural or total spinal block.
68*	3	No	Hypoventilation in spontaneously breathing patient, and hypokalaemia treated with rapid intravenous administration of potassium chloride during general anaesthesia, leading to ventricular fibrillation.
72	1	Yes	Cardiorespiratory arrest, possibly related to intravenous regional block with bupivacaine.
72*	3	Yes	Cardiac arrest during epidural + general anaesthesia. History of pre-operative myocardial infarction. Possible cause intra-operative hypotension and myocardial infarction.
73*	3	Yes	Ventilator disconnexion with alarms switched off in the postoperative period.
76	2	Yes	Myocardial infarction during general anaesthesia. Large dose of lignocaine given during resuscitation because wrong concentration of solution was used.

*Possibly preventable cases.

disease concerned or surgical factors. We consider that these records in spite of these limitations do represent a reasonable picture of anaesthesia-associated complications, near accidents, accidents and faults in our hospital.

Dental damage could be considered a relatively minor accident in terms of patient morbidity but it was the most commonly reported accident. One of the reasons for such frequent reports may have been the anaesthetist's fear of possible litigation or medicolegal problems associated with dental damage. The majority of these occurred in patients with carious teeth or in those who presented as a difficult tracheal intubation.

The reports of cardiac arrests and deaths probably reflect their true incidence. A cardiac arrest or a death which occurs solely or principally as a result of anaesthetic misadventure was very rare. Most of the deaths involved either elderly patients or patients in poor physical condition. Similar conclusions were drawn in the report of the Confidential Enquiry into Peri-Operative Deaths (CEPOD).[4] The incidence of anaesthesia-related cardiac arrest was 1.3 per 10 000 anaesthetics in our study. This is comparable to the incidence of 1.7 per 10 000 anaesthetics reported by Keenan and Boyan.[8] The incidence of fatal cardiac arrests as a result of anaesthesia misadventure in our study was 0.6 per 10 000 anaesthetics as compared to 0.9 per 10 000 anaesthetics reported by Keenan and Boyan.[8]

Table 3. Faults in drug administration.

100% nitrous oxide instead of 100% oxygen at the end of anaesthesia.
Intramusclular suxamethonium instead of ketamine to a child.
Isoprenaline instead of atropine during an episode of bradycardia.
Intravenous sodium citrate instead of potassium chloride.
Intravenous sufentanil instead of alfentanil during general anaesthesia.
Intravenous administration of saline solution which was not intended for intravenous use.
Adrenaline given instead of atropine.
Wrong premedication given.
Overdose of fentanyl during neurolept anaesthesia.
Wrong concentration of lignocaine during cardiorespiratory resuscitation.
Wrong dose of antibiotics to a child.
Interchange of inlet and outlet of halothane (Fluotec) vaporizer leading to overdose.
Rapid intravenous injection of potassium chloride during general anaesthesia.
Ketamine overdose as a result of calculation based on wrong weight of a child.

Fourteen incidents which involved drug administration (wrong drug or wrong dose) were reported but it is probable that the real incidence of such occurrences was much higher. These 14 reported incidents were serious enough to cause anaesthetists to make voluntary reports. Lack of vigilance and carelessness on the part of the anaesthetist were common factors in all these incidents.

The incidence of peripheral neuropathies in this study was 10 times lower than that reported in previous studies.[9,10] Dhunér, in 1950, reported an incidence of 1 per 1000 anaesthetics.[9] Twenty years later, Parks reported one peripheral neuropathy per 700 anaesthetics.[10] Both of these studies involved a retrospective review of the records of all

Table 4. Summary of associated factors with reports of the miscellaneous group.

Associated factors	Numbers
Complications	14
Failure to check	9
Inattention or carelessnes	6
Lack of communication	5
Improper technique	4
Lack of adequate experience	1
Poor maintenance of the operating theatre	1
Total	40

patients who were anaesthetised during the study period. We have reviewed only the reported injuries. It is possible that not all the nerve injuries were reported. Inappropriate body position during anaesthesia was the most commonly involved factor in causation.

It is highly probable that the reports to the FONA committee presented in this paper represent only a proportion of all faults, accidents, near accidents and complications that occur in association with anaesthesia. Nonetheless, we consider that some careful conclusions can be drawn. Anaesthesia continues to be associated with morbidity and mortality despite improvements in drugs and equipment. Human error is the most important factor in the majority of these incidents. It is known that the basis of all accidents or near accidents in any situation is unsafe practices or working conditions.[11] Therefore, in order to assess the risk of anaesthesia, carefully planned and executed prospective studies are needed to study those unsafe practices or conditions which might result in an accident, a fault or a near accident.

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Anaesthesia, 1990, Volume 45, pages 7–10

Changes in haemodynamics and plasma catecholamine concentrations after field block for inguinal herniorrhaphy using lignocaine with adrenaline

P. B. HAYSE-GREGSON, K. J. ACHOLA AND G. SMITH

Summary

Haemodynamic changes and plasma catecholamine concentrations were measured in 12 patients aged 24 to 87 years after performance of a field block for elective repair of inguinal or femoral hernia. The local anaesthetic used comprised a mixture of lignocaine 0.5% with adrenaline 1:200 000; the dose of lignocaine administered varied from 3.8 mg/kg to 4.9 mg/kg. Plasma adrenaline increased by 326% and plasma noradrenaline by 75% at 10 minutes after completion of the block. Mean heart rate increased from 75 to 94 beats/minute after 20 minutes, whilst there were no obvious changes in systolic and diastolic arterial pressures. Potentially serious arrhythmias developed in two patients, thought to be related to the peak plasma concentrations of adrenaline produced. It is recommended that the dose of adrenaline used as described for this block should be reduced.

Key words

Anaesthetic techniques, regional; inguinal field block.
Sympathetic nervous system; pharmacology, adrenaline, noradrenaline.

Large volumes of local anaesthetic solution are needed for field block for inguinal herniorrhaphy.[1–4] Solutions that contain adrenaline are used frequently to reduce the rate of absorption of local anaesthetics and prolong and intensify the block. The procedure is sometimes performed in elderly patients who are considered unfit for general anaesthesia, but for whom high plasma concentrations of adrenaline would be undesirable and potentially harmful.

The recommended maximum dose of lignocaine with adrenaline is 7 mg/kg. This corresponds to approximately 100 ml of 0.5% solution for a 70-kg man.[1,2,5] This volume of the commercially available 1:200 000 strength solution contains 500 μg adrenaline.

Several maximum recommended doses of adrenaline with local anaesthetic have been suggested: 200 μg,[6] 250 μg,[3] and 500 μg.[2,5] A concentration of 1:200 000 adrenaline solution has been reported as optimum to reduce absorption of lignocaine[6] although 1:400 000 has been used satisfactorily for day case inguinal herniorrhaphy.[4]

Recent studies have shown that the degree of absorption of exogenous adrenaline varies according to the site of infiltration (Table 1). The purpose of the present study was to measure alterations in haemodynamic status and plasma catecholamine concentrations in a group of patients after field block for inguinal or femoral herniorrhaphy using a commercially available solution of lignocaine with adrenaline.

Method

The study was approved by the local Ethics Committee, and informed consent was obtained from 12 patients who presented for elective repair of inguinal or femoral hernia; local anaesthesia was considered appropriate in these patients. The surgeons decided two of the patients were unfit for general anaesthesia. Ages ranged from 24 to 87 years, and further patient details are presented in Table 2.

Premedication consisted of a benzodiazepine orally 1–2 hours before surgery, and 1 to 2 mg midazolam was administered intravenously in the anaesthetic room as required. An 18-gauge cannula was placed in a forearm vein under plain local anaesthesia. The ECG was displayed continuously, and arterial pressure measured either by

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Table 1. Summary of other studies of infiltration with adrenaline-containing local anaesthetic solution in awake patients.

Reference	Source	Site of infiltration	Dose of adrenaline μg	Adrenaline baseline (pmol/ml)	Concentration peak (pmol/ml)	Noradrenaline baseline (pmol/ml)	Concentration peak (pmol/ml)
6	Cotton *et al.*, 1986	Brachial plexus	200	0.8	1.8*	2.0	(ns)
7	Barber *et al.*, 1985	Perianal	200	0.23	3.42*	1.63	(ns)
8	Lew *et al.*, 1988	Ears	20	0.8	2.1*	2.5	(ns)
9	Donlon and Moss, 1979	Retrobulbar	50 to 60	0.64	2.3*	3.2	3.8 (ns)

*p<0.05 compared with baseline; ns, not significant.

Table 2. Details of patients and dosages.

Age (years)	Sex	Operation	Weight (kg)	Lignocaine dose mg/kg	Adrenaline dose μg/kg	Adrenaline dose μg
62	M	LIH	88	4.0	4.0	352
27	M	RIH	64	4.7	4.7	301
66	M	RIH	72	4.5	4.5	324
27	M	RIH	64	4.9	4.9	314
84	F	LFH	58	4.3	4.3	249
77	F	LFH	50	4.2	4.2	210
24	M	RIH	62	3.8	3.8	236
87	F	LIH	57	4.0	4.0	228
62	M	LIH	83	3.9	3.9	324
53	M	LIH	62	4.2	4.2	260
47	M	RIH	72	4.0	4.0	288
71	M	RIH	61	4.1	4.1	250

L, left; R, right; H, hernia; I, inguinal; F, femoral.

an automatic arterial pressure recorder or by sphygmomanometry and auscultation of Korotkov sounds.

The field block was carried out according to a standard method.[2] The solution used was 0.5% lignocaine with 1:200 000 adrenaline, and details of drug doses are shown in Table 2. Venous blood samples, 10 ml, were taken before institution of the block, and at 2, 5, 10, 15 and 20 minutes after completion of the block, and transferred immediately to Vacutainer tubes that contained lithium heparin, and centrifuged as soon as possible. The supernatant plasma was stored at −70°C until assayed for adrenaline and noradrenaline concentrations using HPLC as described previously in our laboratory.[10]

The patients were transferred to the operating theatre for surgery after the samples had been taken. The block was effective in all cases. Most patients required further infiltration by the surgeon of 5 to 10 ml local anaesthetic solution around the neck of the hernia sac. No further blood sampling was carried out.

Data were analysed statistically by analysis of variance followed by Student's *t*-test. A value of $p < 0.05$ was regarded as statistically significant.

Results

The mean plasma adrenaline concentration increased from a baseline of 1.06 pmol/ml to a peak of 4.52 pmol/ml at 10 minutes ($p < 0.05$, Fig. 1). Mean plasma noradrenaline concentration increased from a baseline of 4.66 pmol/ml to a peak of 8.22 pmol/ml at 10 minutes ($p < 0.05$, Fig. 2). These values represent increases of 326% and 75% for adrenaline and noradrenaline respectively. Mean heart rate increased from a baseline of 75 beats/minute to a peak of 94 beats/minute at 20 minutes, an increase of 32% ($p < 0.05$, Fig. 3). Systolic and diastolic arterial pressures were essentially unchanged (Fig. 4).

One patient, aged 66, whose pre-operative ECG showed unifocal ventricular extrasystoles, developed frequent multifocal extrasystoles. His baseline noradrenaline and adrenaline concentrations were close to the group mean, and subsequent values lower than the group mean.

Another patient, an 84-year-old female, developed a supraventricular tachycardia 2 minutes after the block. This was treated with verapamil after the samples had been taken. Her noradrenaline concentrations were high; base-

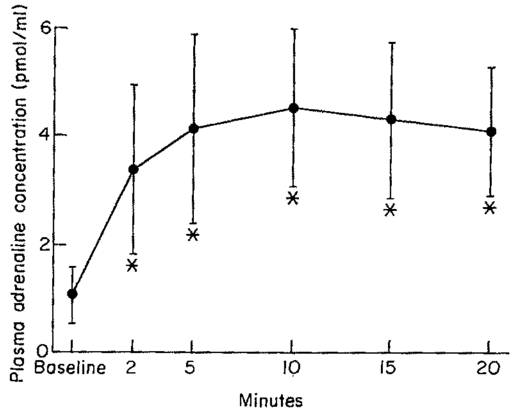

Fig. 1. Changes in plasma adrenaline concentrations before and after completion of field block (mean, SD). × $p < 0.05$ compared with baseline.

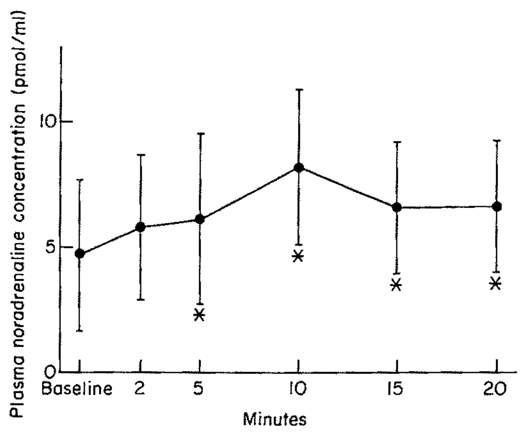

Fig. 2. Changes in plasma noradrenaline concentrations before and after completion of field block (mean, SD). $\times p < 0.05$ compared with baseline.

line 6.2 pmol/ml, peak 10.2 pmol/ml at 10 minutes; corresponding adrenaline levels were: 1.5, and 5.7 pmol/ml.

All patients were calm, some slightly sleepy, with the exception of the 84-year-old who became tremulous during the episode of supraventricular tachycardia. All had excellent postoperative analgesia for 3 to 4 hours.

Discussion

Our baseline mean adrenaline concentration of 1.06 pmol/ml was slightly higher than the values obtained in other studies in resting premedicated patients (Table 2). The baseline mean noradrenaline concentration of 4.66 pmol/ml was higher than those reported in previous studies from this laboratory: approximately 2 pmol/ml.[6,8,10] Low and others,[11] in a study of 16 normotensive and 10 hypertensive unpremedicated patients who had elective vascular surgery, found baseline values of noradrenaline of 3.4 and 3.8 pmol/ml respectively and baseline mean adrenaline concentrations of 1.3 and 1.9 pmol/ml respectively. The mean plasma noradrenaline concentration was 4.8 pmol/ml before induction of anaesthesia[12] in another study of premedicated patients who had upper abdominal surgery.

Premedication in the present study was not standardised because of the wide range in age and health of the patients. Midazolam was administered in the anaesthetic room according to individual requirements. Our patients ranged in age from 24 to 87 years, and while it has been reported that noradrenaline concentration increases with age,[13] the correlation between age and noradrenaline concentrations in this small group of patients was poor.

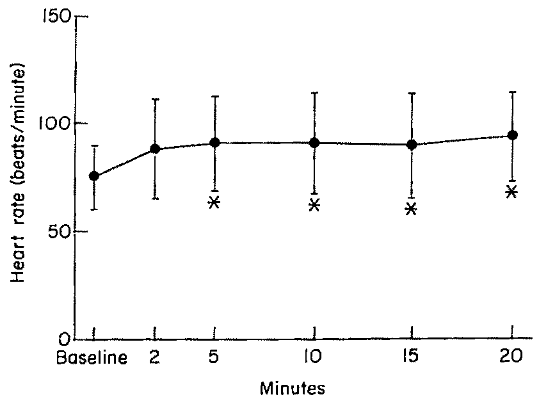

Fig. 3. Changes in heart rate before and after completion of field block (mean, SD). $\times p < 0.05$ compared with baseline.

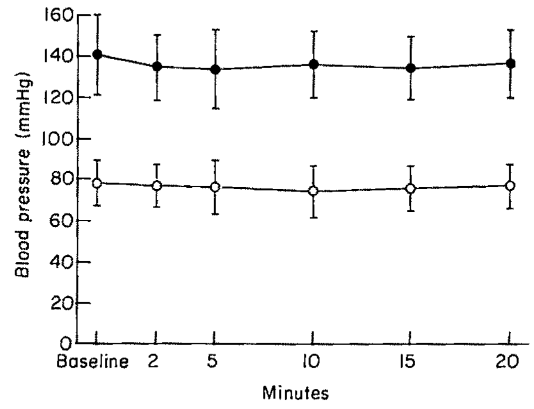

Fig. 4. Changes in arterial pressure before and after completion of field block (mean, SD). ●, Systolic; ○, diastolic.

The large increase in plasma adrenaline concentration after institution of the field block was accompanied by a smaller but nevertheless significant increase in plasma noradrenaline concentration. The absence of a matched control group weakens the inference that these changes were caused by the administration of adrenaline.

The increase in plasma adrenaline concentration after infiltration with adrenaline has not, in previous studies, been accompanied by an increase in plasma noradrenaline concentration.[6-8, 14] It is likely therefore that some of the increase in adrenaline observed in our study was caused by the stress or discomfort produced by the field block. The perceived somatic effect of the absorbed adrenaline (tachycardia) may have caused sympathetic stimulation.[15]

In studies of the stress response to tracheal intubation, the changes in plasma concentrations are mirrored frequently by a similar increase in plasma noradrenaline concentrations.[16] The greater percentage change in adrenaline concentrations in the present study suggests that this increase was caused partly by stress and partly by systemic absorption of adrenaline. It has been suggested[16] that this peak[5] value of adrenaline observed in this study is undesirably high and it is possible therefore that there is a causal relationship between these levels and the arrhythmias observed in two patients.

In conclusion, field block for inguinal herniorrhaphy using 0.5% lignocaine with 1:200 000 adrenaline in apparently moderate doses gave rise to significant increases in plasma adrenaline and noradrenaline concentrations and heart rate, and were associated with potentially serious arrhythmias in two patients. It is recommended that the dose of adrenaline used as described in the study should be reduced.

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Alkalinisation of prilocaine for intravenous regional anaesthesia

P. ARMSTRONG, M. BROCKWAY AND J. A. W. WILDSMITH

Summary

Ten volunteers underwent intravenous regional anaesthesia on two separate occasions using 40 ml prilocaine 0.5% to which was added 5 ml of either saline 0.9% or sodium bicarbonate 8.4%. Addition of sodium bicarbonate decreased the time of onset of loss of sharp touch and temperature sensations and of motor power. Time to full recovery of the arm was slower with the alkalinised solution and nine of the subjects preferred this block. The addition of sodium bicarbonate to prilocaine for intravenous regional anaesthesia may be clinically useful.

Key words

Anaesthetics, local; prilocaine, alkalinisation.
Anaesthetic techniques; intravenous regional.

Intravenous regional anaesthesia (IVRA) is a simple, commonly used technique. However, the analgesia may be incomplete and of slow onset, and after release of the tourniquet analgesia usually disappears rapidly. Attempts have been made to speed the onset by using larger doses of local anaesthetic drug[1] and to prolong the duration of analgesia after cuff release by the use of longer acting agents. However, complications have occurred; large doses have caused serious systemic effects[2] and the use of bupivacaine has been associated with severe reactions.[3]

Other methods have been employed both to hasten and prolong the analgesia. Dextran had only a moderate effect[4] whilst the addition of potassium[5] had none at all. More rapid onset and prolonged duration of analgesia is achieved in brachial plexus[6] and sciatic nerve block[7] by increasing the pH of bupivacaine. Consequently, we decided to investigate the effects of alkalinisation of prilocaine during IVRA in volunteers.

Subjects and methods

Ten healthy, fasted, male volunteers aged 27 to 35 years acted as subjects in the study, which had received approval from the local ethics committee. Each subject received on two occasions, separated by at least 5 days, IVRA of the nondominant upper limb using a standard technique.

A 22-G indwelling cannula was inserted into a prominent vein on the ulnar side of the dorsum of the hand; the same site was used in both occasions. A padded pneumatic tourniquet was placed round the upper arm at its broadest point, the arm was exsanguinated using an Esmarch bandage, and the tourniquet was inflated to 250 mmHg. The Esmarch bandage was removed and 45 ml of solution was injected over 45 seconds; the end of the injection was taken as time zero. The solution consisted of 40 ml of prilocaine hydrochloride 0.5% to which had been added 5 ml of either saline 0.9% or sodium bicarbonate 8.4%. Addition of the sodium bicarbonate increased the pH of the prilocaine solution from 6.40 to 7.75 (we had established that no precipitation was apparent up to 21 days after the addition). The solutions were administered in a randomised double-blind fashion.

Sensory blockade was assessed using a short bevelled needle at one-minute intervals from the end of the injection; the blinded subject reported the sensation as sharp, touch or absent. Additionally, cold sensation was assessed using an ethyl chloride spray. Six sites were assessed (Fig. 1), chosen for their representation of small peripheral nerve branches.[8] Motor power was tested at one-minute intervals by asking the subject to squeeze a 500-ml infusion bag connected to a pressure transducer.[5]

The tourniquet was deflated and removed 20 minutes after the end of the injection. Objective testing of sensation continued until full recovery had occurred at all six sites. The subjects reported the time taken for the arm to return completely to normal and any sensations experienced

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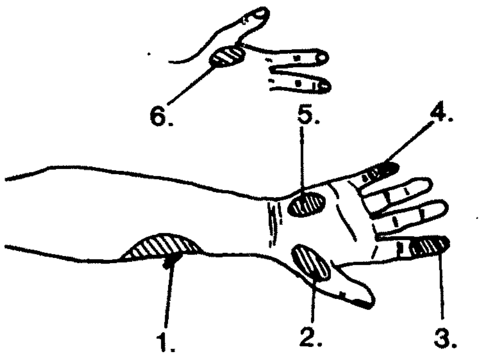

Fig. 1. Sites chosen for sensory testing. 1, forearm (radial nerve); 2, thenar eminence (median nerve); 3, index finger (median nerve); 4, little finger (ulnar nerve); 5, hypothenar eminence (ulnar nerve); 6, first webspace (radial nerve).

during the injection or after cuff release. They were asked to state which block felt the more intense.

The results at each of the six sites for times to loss and recovery of pinprick, touch and temperature sensation were analysed using Wilcoxon signed rank tests. A p value of less than 0.05 was accepted as significant.

Results

Loss of pinprick sensation always preceded loss of touch sensation and all six sites were insensitive to all stimuli within 20 minutes. Onset of block to each of the sensations tested was faster at every site, and return of sensation was slower, if sodium bicarbonate was added to the prilocaine (Figs 2–4). Twenty-one of the 36 differences were statistically significant (Table 1). Loss of motor power was faster and recovery slower when sodium bicarbonate was used (Fig. 5).

The mean time taken for full recovery of sensation was statistically longer ($p = 0.0002$) after sodium bicarbonate (Table 2). Nine subjects preferred the block with sodium bicarbonate and one preferred the saline block. One subject (the smallest in the group) experienced tinnitus after cuff release on both occasions. No other sequelae were reported.

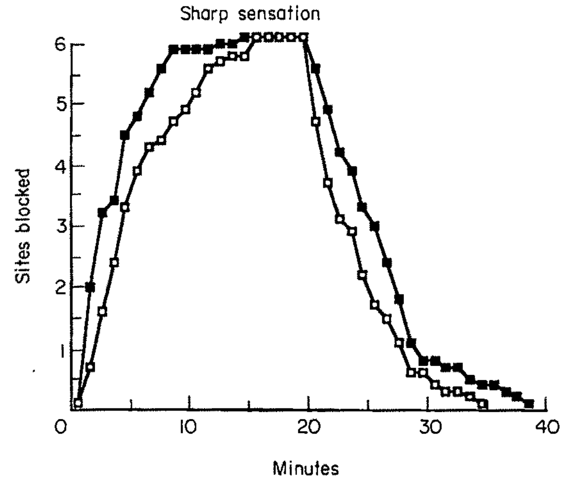

Fig. 2. Time course to onset and recovery of blockade to sharp pinprick. ■—■, 8.4% NaHCO$_3$; □—□, saline.

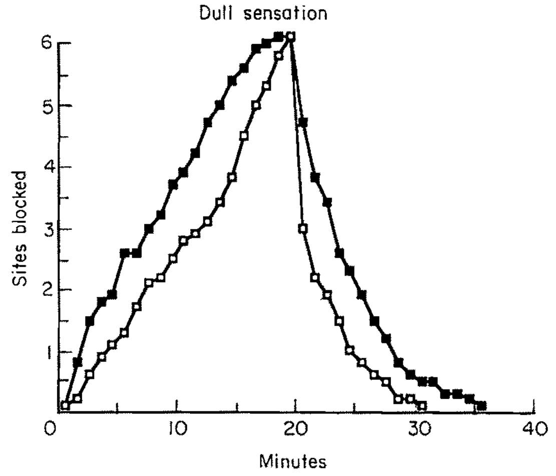

Fig. 3. Time course to onset and recovery of blockade to touch ■—■, 8.4% NaHCO$_3$; □—□, saline.

Discussion

Local anaesthetics exist as either ionised or uncharged molecules, the relative proportions of each being related to the pKa of the drug and the pH of its environment; the proportion that is uncharged increases at a higher pH. The ionised drug is the active form, but to reach its site of action at the nerve membrane it needs to pass through many lipid membranes.[9] Sodium bicarbonate increases the pH of the solution, and thereby increases the amount of uncharged base present; this could allow a greater mass of drug to reach the site of action at a faster rate. This may result in a decrease in the time to onset of action and may increase the intensity of the block.

The majority of studies have shown this beneficial effect. Addition of sodium bicarbonate to lignocaine[10,11] and 2-chloroprocaine[12] increased their effects in epidural anaesthesia. Alkalinisation of bupivacaine has been shown to have a beneficial effect in brachial plexus,[6] sciatic nerve[7] and peribulbar[13] blocks. However, other studies have shown that sodium bicarbonate had no influence on the effect of bupivacaine for brachial plexus block[14] or for epidural anaesthesia.[15]

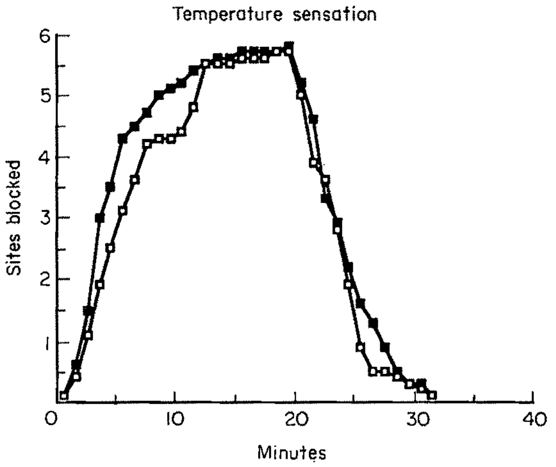

Fig. 4. Time course to onset and recovery of blockade to cold ■—■, 8.4% NaHCO$_3$; □—□, saline.

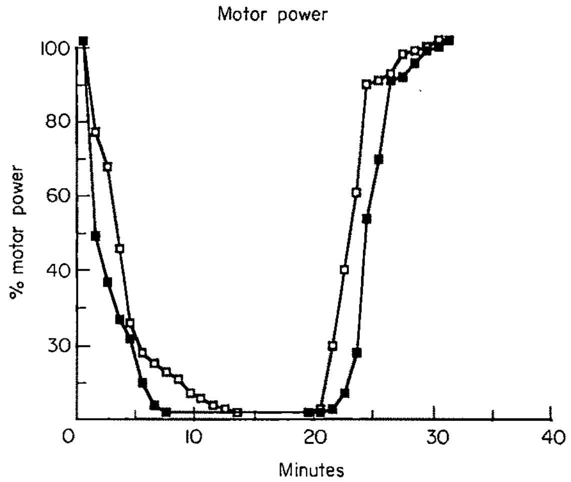

Fig. 5. Time course to onset and recovery of motor blockade. ■—■, 8.4% $NaHCO_3$; □—□, saline.

The pH of the bupivacaine solution in all these studies was increased only to the range 6.82–7.15. The pKa of bupivacaine is 8.1; these modest increases result in no more than 15% of the drug being in the base form. The effect of alkalinisation at this level may be only marginal and this may explain why some workers have been unable to demonstrate an effect. Unfortunately, increasing the pH of bupivacaine further leads to precipitation. Prilocaine is stable in solution at pH values close to its pKa (7.9) and thus a solution that contains almost 50% of the base drug can be injected.

Alkalinisation may cause more local anaesthetic to be absorbed by the tissues as well as increasing the rate of absorption. This would take longer to wash out, so extending the duration of the block; an additional advantage might be a decrease in the risk of toxic reactions after cuff release. Normally 30% of the total dose is released into the systemic circulation immediately, with a gradual release of the remainder.[16] Less bupivacaine was released immediately after cuff deflation in the forelimb of a dog after the solution had been alkalinised with sodium bicarbonate.[17]

Table 1. Number of sites at which the alkalinised solution caused a statistically significant ($p<0.05$ with Wilcoxon signed rank test) faster onset or slower recovery of each sensation.

Sensation	Onset	Recovery
Pinprick	5/6	3/6
Touch	4/6	4/6
Temperature	3/6	2/6

Table 2. Mean (SD) time (minutes) for arm to return subjectively to normal ($p<0.001$ using Wilcoxon signed rank test).

Prilocaine 0.5% + saline pH = 6.40	Prilocaine 0.5% + $NaHCO_3$ pH = 7.75
34.0 (10.9)	61.5 (15.2)

In conclusion, the addition of sodium bicarbonate to prilocaine 0.5% for IVRA hastens the onset of analgesia and loss of power significantly whilst recovery occurs at a slower rate on release of the tourniquet. This effect appears to be of significance in volunteers and its value in clinical practice requires to be evaluated.

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Anaesthesia, 1989, Volume 45, pages 14–17

Local anaesthesia for eye surgery

The peri-ocular technique

R. A. FRY AND J. HENDERSON

Summary

A technique of peri-ocular infiltration of local anaesthetic for eye surgery is described. The ease of administration of this form of local blockade is highlighted and its low propensity for complication compared with retrobulbar blockade. The involvement of anaesthetists in the performance of local anaesthesia for ophthalmic surgery that utilises this technique is encouraged.

Key words

Anaesthesia; ophthalmic.
Anaesthetic techniques; regional, peri-ocular.

Involvement of the anaesthetist in the provision of local anaesthesia for eye surgery has tended to be limited to the interested minority. This situation has evolved because of the potentially catastrophic complications of retrobulbar infiltration especially retrobulbar haemorrhage, optic nerve damage, bulbar perforation, central retinal artery occlusion and intradural injection.[1–3] Little attention has been drawn to the technique of peri-ocular infiltration which is simple to perform, has a low incidence of even minor complications when conducted with care, and provides a reliable alternative to retrobulbar anaesthesia.

It was first described as a specific local anaesthetic block by Davis in 1986; however, nonspecific local anaesthetic infiltration of the peri-ocular space has been used previously with success.[4,5] It has been extensively utilised by the authors and proved to be extremely useful. Over 800 peri-ocular anaesthetic infiltrations have been performed by the authors with no complications and one single documented failure, who required the addition of 1 ml of local anaesthetic injected into the muscle cone pre-operatively as for a retrobulbar injection.

Technique

The patient is placed in a supine position with his head resting on a small pillow. The eye is swabbed with an appropriate cleansing solution. The injectate is prepared by dissolving 500 IU hyaluronidase in a mixture of local anaesthetic, comprised of 2% lignocaine and 0.5% bupivacaine in equal proportion to a volume of 12–15 ml.

A small skin wheal is raised in the lower lid, with a 25-gauge needle, just superior to the inferior orbital rim, approximately 1.5 cm medial to the lateral canthus, using 0.5 ml of 2% lignocaine. The procedure is then repeated for the upper eyelid, 1–2 mm medial and inferior to the supraorbital notch.

A standard blunt 1.25-inch Atkinson needle is then advanced through the skin wheal at the lower orbital margin with the bevel directed towards the orbit (Figs 1 and 2). A distinctive 'pop' is often felt as it passes through the lower orbital septum (Fig. 3). This is less apparent in the elderly. The needle is then advanced past the inferior orbital margin towards the equator of the eye where it is angled in a superomedial direction. Four millilitres of solution are injected after aspiration, at a depth of approxi-

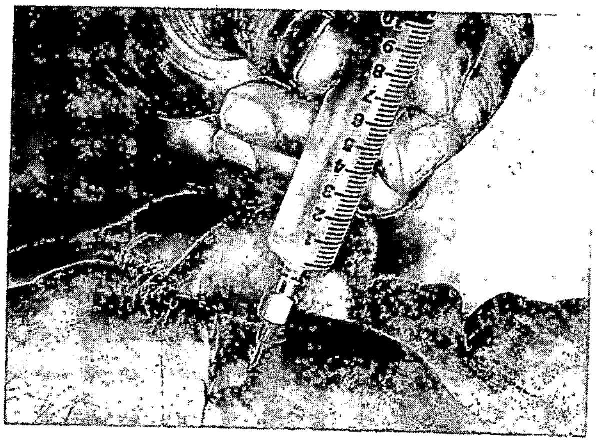

Fig. 1. Inferior injection site; needle advanced towards the equator of the eye.

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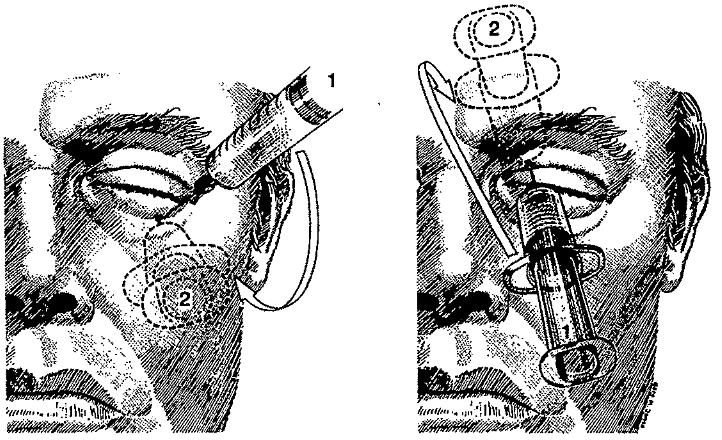

Fig. 2. Line drawing that depicts the positions inferiorly and superiorly of entry of the needle from the anterior aspect. Position 1, needle entry; position 2, full needle insertion.

mately 2.5 cm. The tension within the orbital tissues is monitored during the injection by testing eyeball movement by means of lid palpation. There is a temporary period of proptosis at this stage caused by the injectate, and conjunctival oedema is almost invariably noted (Fig. 4). One millilitre of solution is delivered to the orbicularis oculi muscle on withdrawal of the needle.

The needle is then introduced to the upper skin wheal aimed at the roof of the orbit, parallel to the nose and advanced posteriorly over the eyeball to the depth of approximately 2 cm (Figs 2 and 5). It is then directed medially and advanced 0.5 to 1 cm; 2–3 ml of solution are deposited, and eyeball tension is again checked (Fig. 6). A further 1 ml is introduced to the substance of the orbicularis oculi muscle on withdrawal.

A Honan or similar pressure cuff is then applied to the eye for 10 minutes by which time the block is usually well established, although occasionally up to 20 minutes is required.[6]

It should be noted that although average volumes are quoted, each eye is individual and at times up to 20 ml of injectate have been used on initial injection. This is especially true of the elderly where poor orbital septae may allow excessive leakage of the injectate from the immediate peri-ocular space. This is seen as oedema of either eyelid, or both upper and lower eyelids together, and occurs to differing degrees in all patients. It rapidly disappears after application of the pressure cuff.

The orbicularis oculi muscle in younger patients is often somewhat reactive after simple intramuscular injection. It is advisable to infiltrate a further 1 ml of solution alongside the lateral canthus of the eye to prevent spasm by blocking the local branches of the facial nerve, as described by Van Lint.[7] This can be conducted through the same lower lid injection site.

It is advisable to check the degree of blockade at 5 minutes after application of the pressure cuff, and complete akinesia is an excellent end point although not essential. A further 3–4 ml of solution can be infiltrated if mobility is still present in any direction. In general, the lower injection is repeated for inferiolateral movement and the upper injection for superomedial movement.

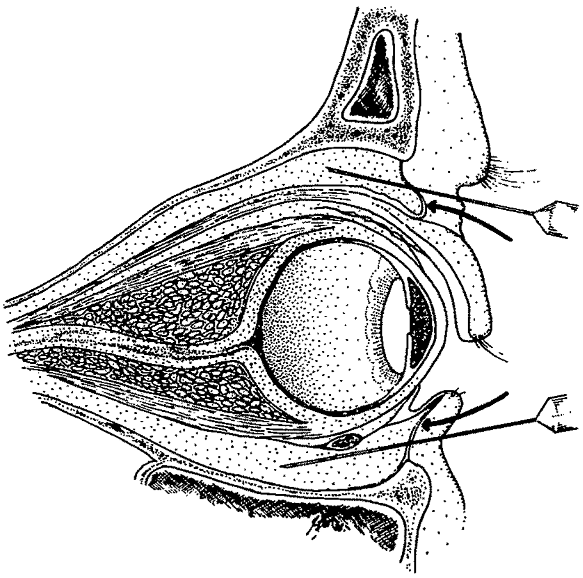

Fig. 3. The superior and inferior orbital septa with needles *in situ* (arrows indicate septa).

Discussion

Simple anatomical consideration of the needle paths in peri-ocular infiltration indicates the probability of a

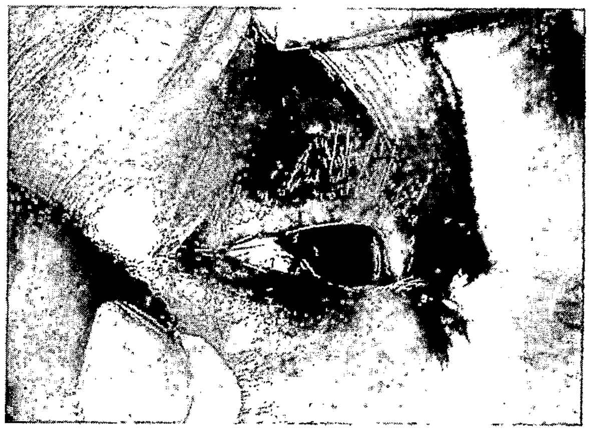

Fig. 4. Typical conjunctival oedema developed during peri-ocular infiltration.

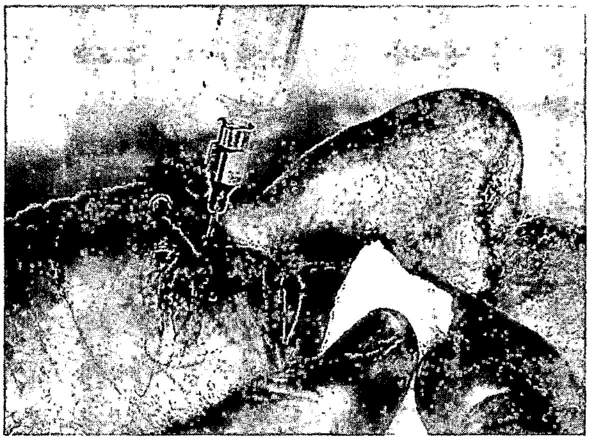

Fig. 5. The needle advanced parallel to the nose along the roof of the orbit.

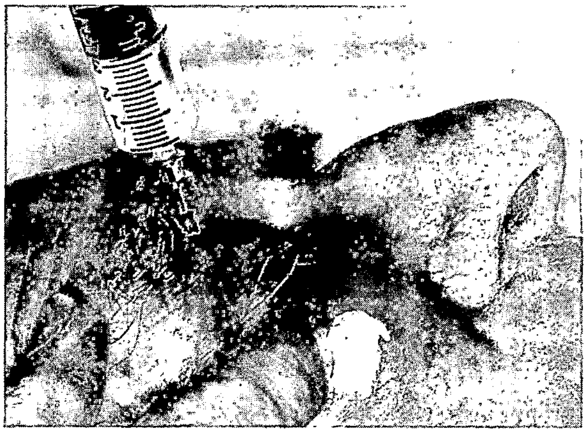

Fig. 6. Superior injection site; index finger tests eyeball tension.

reduced incidence of major complications traditionally associated with retrobulbar anaesthetic blockade. These include retrobulbar haemorrhage, optic nerve damage and intradural injection. There is no statistical evidence for this as yet, although a detailed literature search recently highlighted only one major complication in the performance of peri-ocular infiltration for eye surgery. An isolated perforation of the globe was reported in an elderly myopic patient.[8] This is also a complication of retrobulbar injection, and one report by Ramsay *et al.*[9] described three perforations, also in large myopic eyes, out of 4000 retrobulbar injections, whereas Davis *et al.* had no complications in over 2000 periorbital blocks.[1] No further reports of complications that arise from this form of anaesthesia have been found in any other publications. Global perforation should not occur with attention to technique, especially correct angling of the needle, careful direction of the needle bevel towards the globe and perhaps avoidance of especially large, myopic eyes.

Minor complications which can be anticipated with peri-ocular infiltration rarely if ever alter the course of surgery or postoperative management. These include peri-orbital ecchymosis, subcutaneous spread of local anaesthetic to the opposite eye with partial ptosis, and complaints of transient brightness on initial exposure to the operating microscope. These rarely persist. Other advantages include minimal discomfort from the facial nerve block and less visual extinction, about which pre-operative explanation of the technique reassures the patient.

The use of a combination of two local anaesthetics, 2% lignocaine and 0.5% bupivacaine, was essential for the establishment of an acceptable level of both sensory and motor[10] anaesthesia. Bupivacaine alone or with proportionally smaller volumes of lignocaine resulted in a more prolonged but poorer blockade of slow onset, whereas lignocaine alone had a rapid onset with excellent motor blockade, but was of too short a duration for most surgery. The two agents, 0.75% bupivacaine and 1% etidocaine, which can be used satisfactorily alone for this technique, are unavailable in New Zealand.

The action of the local anaesthetic in peri-ocular space is assumed to be through orbital diffusion to the third, fourth, fifth, sixth and seventh cranial nerves or branches thereof, and also to the ciliary ganglion.[1]

In general, no premedication is utilised by the authors in patients who have peri-ocular blockade, since cooperation, especially in the elderly, is better during surgery when these are omitted. Some advocate the use of induction agents before administration of local eye blockade, but this is unwarranted, since the block is well tolerated by the awake patient and their use exposes the patient to unnecessary hazard.[11–14]

The method presented is simple to learn and perform. The onset time of blockade is not as rapid as that seen with retrobulbar injection, but the method has a very low incidence of complications. Certainly the slower onset time of the block, compared to a retrobulbar technique, is not a factor contraindicating its use when performed by the anaesthetist. The involvement of the anaesthetist who performs the blocks eliminates the time factor between cases, allows increased case loads through theatre and enhances patient safety.

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Anaesthesia, 1990, Volume 45, pages 18–21

Tussive effect of a fentanyl bolus administered through a central venous catheter

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Summary

One hundred and ten male patients scheduled for coronary artery bypass grafting were allocated randomly into one of three groups. Patients in group A received fentanyl 7 μg/kg via a central venous catheter, those in group B were given fentanyl 7 μg/kg through a peripheral venous cannula, and patients in group C received sterile water via a central venous catheter. In group A, 45.9% of patients coughed after injection of fentanyl; the mean onset time from the end of fentanyl administration to the beginning of coughing was 10.6 seconds. Only one patient in group B and no patient in the control group exhibited a cough response ($p < 0.0001$). We hypothesise that fentanyl can evoke the pulmonary chemoreflex.

Key words

Anaesthetics, intravenous; fentanyl.
Complications; cough.

The opioid agonist fentanyl has been used as an anaesthetic adjunct as well as the sole anaesthetic for almost two decades.[1-3] Common side effects of fentanyl such as respiratory depression have been reported and studied in detail.[4-6] Lately, the focus has shifted to the discussion of complications such as chest-wall rigidity[7-9] and extremely rare seizures associated with fentanyl administration.[10-12] This clinical study deals with a side effect of fentanyl which has not been reported previously.

Materials and methods

One hundred and fifty male patients scheduled for coronary artery bypass grafting gave their informed consent to participate in this institutionally approved study. Exclusion criteria were poor left ventricular function, critical left mainstem stenosis and a history of pulmonary disease including coughing. Patients were premedicated with midazolam 0.1 mg/kg intramuscularly 30 minutes before arrival in the operating room. One peripheral venous cannula was placed in the dorsum of the hand before induction of anaesthesia, and a central venous catheter was inserted via an antecubital vein using intravascular electrocardiography.[13-15] Both procedures were completed successfully in 111 patients. Baseline haemodynamic variables and the degree of sedation were recorded. One patient was eliminated from the study because of unexpected coughing before randomisation. The remaining 110 patients were allocated randomly into one of three groups. Patients in group A ($n = 37$) received a bolus of fentanyl 7 μg/kg administered through the central venous catheter over one second. Patients in group B ($n = 37$) were given fentanyl 7 μg/kg through the peripheral venous line, also over one second. Sterile water in an amount equivalent to the corresponding volume of fentanyl was administered to patients in group C ($n = 36$) via the central venous catheter, again over one second. All injectates were at room temperature.

All patients were observed carefully in order to detect a cough response after injection of fentanyl or sterile water. The onset time from the end of bolus administration until the beginning of coughing was measured using a stopwatch. Where appropriate, the coughing intensity was recorded. The degree of sedation at the time of injection was noted simultaneously.

The osmolality of fentanyl was measured by means of an automatic semi-micro osmometer (Knauer, Oberursel, West Germany). We determined the osmolality of fentanyl as 2 ± 1 mosm/kg water, a result similar to that of Bretschneider.[16] We used sterile water as a control in group C in order to exclude a tussive effect of fentanyl on the basis of its low osmolality.

Statistical evaluation of the incidence of coughing was performed using Chi-square analysis. Differences were considered significant at $p < 0.0001$.

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Table 1. Incidence of coughing and onset times in three groups of patients. Group A received fentanyl 7μg/kg via the central venous catheter, group B fentanyl 7μg/kg via the peripheral intravenous route, and group C sterile water via the central venous catheter (in an amount equal to the volume of fentanyl). All boluses were administered over one second. Age and onset time are expressed as mean (SD).

Group	*n*	Age (years)	Coughing (% of total)	Onset time (seconds)
A	37	61.4 (9.5)	17* (45.9%)	10.6 (2.5)
B	37	62.7 (7.9)	1 (2.7%)	9
C	36	63.1 (8.1)	0 (0.0%)	—

$^*p<0.0001$, group A versus group B or C.

Results

Table 1 summarises the results of the study. Seventeen of the 37 patients in group A coughed after injection of fentanyl through the central catheter. The mean onset time from the end of bolus administration to the beginning of coughing was 10.6 seconds. There was no correlation between coughing and the degree of sedation caused by premedication; the cough response occurred in awake as well as in sleeping, heavily sedated patients. Usually, there were two to four coughs in sequence, without intervening inspirations. In four of the 17 patients who coughed after fentanyl there was a staccato series of 8–15 cough efforts.

The results in group A were significantly different from those in group B (Chi-square = 16.25; $p < 0.0001$) and group C (Chi-square = 21.56; $p < 0.0001$). One patient who was given fentanyl via the peripheral intravenous route (group B) responded with a cough after a delay of 9 seconds. No patient in the control group (sterile water injection) showed a cough response.

Discussion

Opioid agonists like fentanyl are centrally-acting antitussive agents.[17,18] This central action is mediated by distinct receptors located in the medulla oblongata. Our study appears to contradict the classical textbook description in that 45.9% of patients showed a cough response after fentanyl was given via the central venous catheter. In four of these patients, fentanyl elicited a coughing attack. This evoked response was not obtained when the drug was given through a peripheral vein; only one patient coughed, and this event could have been incidental. It appears that a high concentration of fentanyl is required in the central venous system to elicit this cough reflex. Sudden pressure or volume changes in the right ventricular inflow tract caused by the injection of fentanyl would have occurred also in patients in group C, who received sterile water in a volume equivalent to that of fentanyl.

Fentanyl has a known central sympatho-inhibitory effect.[19] It activates vagal efferent fibres[20] which produce predominantly cardiovascular side effects such as bradycardia and hypotension; these are reversible by administration of naloxone.[21,22] The parasympathetic nervous system plays a major role in the regulation of bronchomotor tone.[23,24] Activation of the vagus nerve causes bronchoconstriction, which is closely related to, and may even cause, coughing.[25,26] Bronchoconstriction and bronchospasm can also be elicited by peripheral mediators such as histamine.[26–28] Indeed, coughing has been reported as an early sign of an adverse reaction to Althesin associated with bronchospasm.[29–31] We do not believe that these mechanisms are primarily involved in the pathogenesis of coughing after administration of fentanyl.

Opioid analgesics may increase the tone of smooth muscle. Fentanyl can cause constriction of tracheal smooth muscle, bronchoconstriction, spasm of the sphincter of Oddi, and enhanced tonicity of the pyloric and anal sphincters. It can augment the tone of the ureter, of the detrusor muscle, and of the vesical sphincter.[32–36] The close relationship between bronchial constriction and subsequent coughing can be ascribed to the deformation of irritant receptors. These rapidly adapting stretch receptors are located in the airway wall,[37,38] and they are influenced by deformation of the wall secondary to smooth muscle contraction. Activation of irritant receptors by bronchoconstrictor agents is well documented.[39,40] Irritant receptors, which are sometimes termed cough receptors,[38,41] are stimulated by many inhaled substances such as ammonia, diethyl ether, and sulphur dioxide.[42] The cough receptors initiate the cough reflex; the afferent pathway is contained within the vagus nerve and the efferent component within the somatic nervous system.[43–45] Irritant receptors are primarily mechanoreceptors[39,46] which can be stimulated directly via the pulmonary vascular system. Diatrizoate, a contrast agent used in selective pulmonary angiography, has an osmolality of 1940 mosm/kg and caused coughing in 64% of patients, whereas ioxaglate with an osmolality of 600 mosm/kg elicited coughing in only one of 25 patients.[47] Fentanyl has the same osmolality as sterile water;[16] thus osmotic stimuli did not play a role in our study. Fentanyl and sterile water were both injected at room temperature, and so temperature was also not a causative factor.[48]

We think it is unlikely that the tussive action of fentanyl was initiated by stimulation or irritant receptors. Irritant receptors are generally less sensitive to chemicals than airway endings with afferent vagal C-fibres.[49,50] Pulmonary C-fibres (J-receptors) mediate the pulmonary chemoreflex, which can be evoked by miscellaneous chemicals including amidines, ammonia, and lobeline.[28,51,52] This lung chemoreflex is initiated when intravenously injected chemical substances reach the J-receptors, which are readily accessible from the vascular bed.[53,54] In animals, the chemoreflex response consists of bradycardia, hypotension, and apnoea followed by rapid shallow breathing. In man, this lung reflex consists of a cough response, which is elicited when lobeline sulphate is injected into the pulmonary artery.[52] A cough response is not associated with the lung chemoreflex in experimental animals.

We hypothesise that fentanyl can evoke the pulmonary chemoreflex. It has been documented in Wistar rats that an enkephalin-analogue can stimulate pulmonary J-receptors.[55] Moreover, clinical studies have shown that 70–75%

of fentanyl is sequestered by the lung after intravenous administration during the first pass through the pulmonary circulation.[56–57] The relatively long onset time of 10.6 seconds could be explained by the mediation of opioid receptors, which might be located near the vagal pulmonary J-fibre endings.

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Anaesthesia, 1990, Volume 45, pages 22–25

CASE REPORT

Cardiac arrest after isoflurane anaesthesia in a patient with Duchenne's muscular dystrophy

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Summary

An 8-year-old boy known to have Duchenne's muscular dystrophy suffered a cardiac arrest 10 minutes after he regained consciousness after isoflurane anaesthesia for an orchidopexy procedure. Resuscitation was successful 2 hours after the start of external cardiac compression and after correction of hyperkalaemia and the administration of dantrolene. He later developed myoglobinuria, elevated creatine kinase and a metabolic and respiratory acidosis. He demonstrated a delayed increase in rectal temperature.

Key words

Complications; Duchenne's muscular dystrophy, malignant hyperthermia, rhabdomyolysis.
Anaesthetics, volatile; isoflurane.

Duchenne's muscular dystrophy can be associated with cardiac arrest during anaesthesia. To date such cases have been reported only in patients who have had either halothane or suxamethonium or both. Several cases of cardiac arrest have been linked to malignant hyperthermia, but most appear to be a result of rhabdomyolysis and subsequent hyperkalaemia.

Case history

An 8-year-old boy who weighed 30.2 kg was admitted for a left orchidopexy and division of penile adhesions. Four years previously he had been diagnosed as having Becker's muscular dystrophy after a muscle biopsy at Hammersmith Hospital. Initial screening showed an elevated creatine kinase. An ultrasound of various leg muscles was mildly abnormal and electromyography showed a largely normal pattern, but with some polyphasics. A needle biopsy of his quadriceps muscle was performed on this basis and revealed dystrophic changes. The clinical mildness of the condition distinguished between the Becker and Duchenne types of muscular dystrophy. He was able to ride a bicycle and was a keen swimmer at the time of the present admission. He was slower at running than his peers and experienced mild cramps and difficulty in climbing stairs after exercise, especially in cold weather. Both parents and two sisters were healthy and there was no family history of muscular dystrophy. Creatine kinase levels performed at the Hammersmith Hospital and DNA testing at Guy's Hospital confirm that the mother and eldest sister are both carriers of the muscular dystrophy gene (Fig. 1). Neither the mother nor father had received a general anaesthetic previously; the eldest sister, however, had received three without complication.

Anaesthesia

No premedication was prescribed other than EMLA cream. Induction of anaesthesia was with thiopentone 5 mg/kg and 1.6 μg/kg fentanyl through a 22-G cannula in the dorsum of the left hand. Anaesthesia was maintained with 50% nitrous oxide in oxygen and isoflurane 1.5%; ventilation was spontaneous via a Bain breathing system. The incision was infiltrated with 0.5% plain bupivacaine by the surgeon. The ECG, pulse oximetry and temperature were monitored throughout anaesthesia which lasted 35 minutes and was uneventful.

The patient was alert, conscious and complained of mild discomfort on arrival in the recovery area. The ECG and temperature continued to be monitored. He complained of feeling sick and subsequently became cyanosed and pulseless 10 minutes after arrival. The ECG monitor showed asystole.

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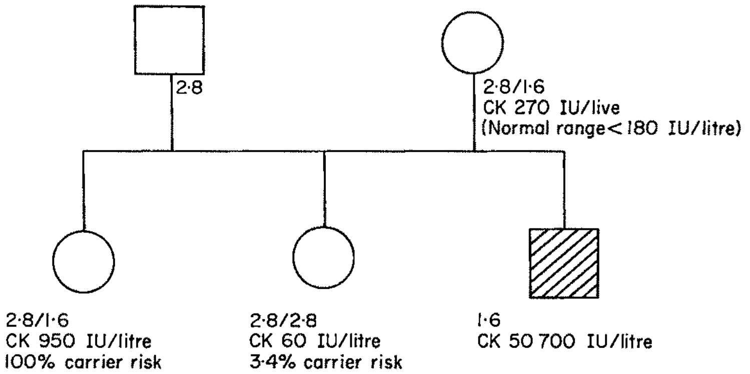

Fig. 1. Family tree showing the carrier status of the immediate family. CK is elevated in the mother, eldest sister and the patient. pERT 87/15 gene probe was used for DNA testing to detect carrier status. The 1.6 allele is implicated as the Becker gene. The two results can be used to determine the carrier risk for the rest of the family.

His trachea was intubated with a 7.0-mm plain tracheal tube and his lungs were hand ventilated via a Waters' system with 100% oxygen. External cardiac compression was started and blood was taken to measure serum electrolytes. A variety of drugs were administered in the meantime, without success, in an attempt to revert to sinus rhythm; these included atropine 0.3 mg, 7 × 0.5 mg adrenaline, 2 × 5 ml 10% $CaCl_2$, 75 mmol $NaHCO_3$ and an isoprenaline infusion. His heart was defibrillated five times.

The first results came to hand after resuscitation had been underway for 30 minutes. Creatine kinase was elevated and serum potassium was greater than 12 mmol/litre; this was immediately repeated. An infusion of 50% dextrose and 10 units of insulin was started. The initial response of the serum potassium to this was slow. The patient was still receiving external cardiac compression at this stage. It was then decided to administer dantrolene 1 mg/kg, despite the fact that at no stage had the temperature become elevated. Three doses were given during the resuscitation.

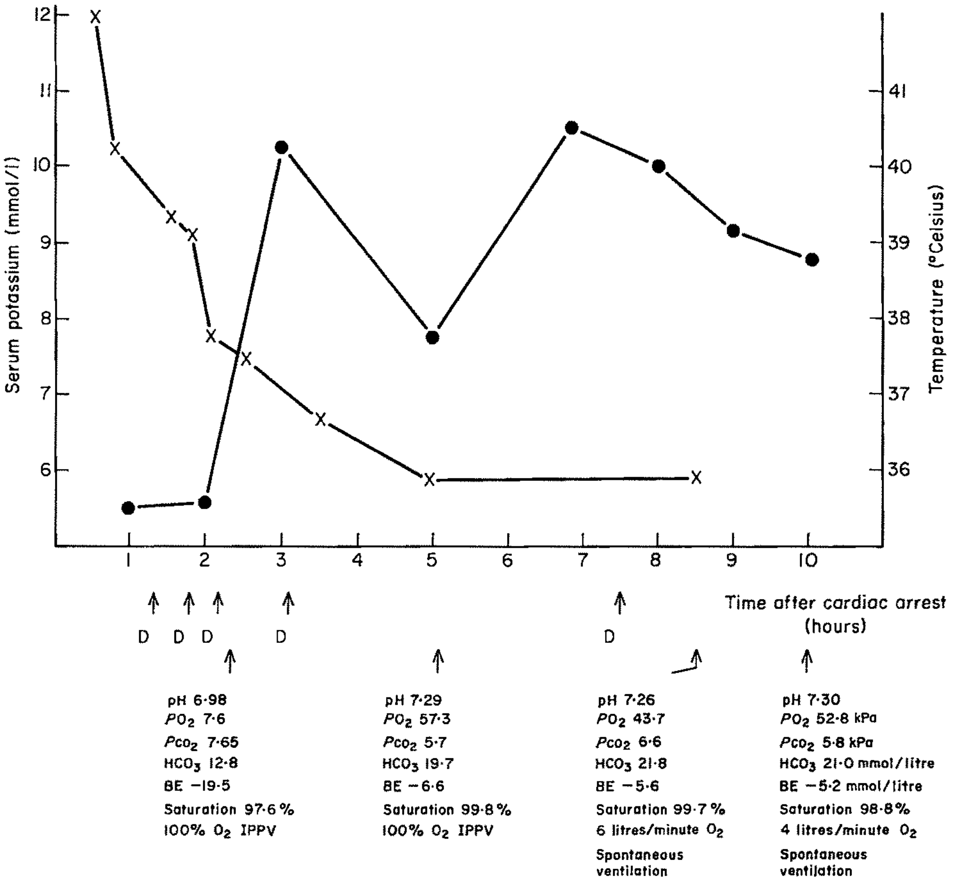

Fig. 2. Graph that shows the results of sequential serum potassium levels, arterial blood gas analysis and temperature readings. × —— ×, serum potassium; ● —— ●, rectal temperature; D, dantrolene.

It was not until 2 hours after resuscitation began that the patient reverted to sinus rhythm with a sustained cardiac output. His serum potassium at this stage was 7.4 mmol/litre. He was transferred to the intensive care unit. Arterial blood gases revealed a metabolic and respiratory acidosis and he developed myoglobinuria. In addition, his rectal temperature began to increase, and peaked at 40.2°C, 3 hours after the arrest began. Further dantrolene was given, and the temperature subsided to 37.8°C only to increase to 40.5°C 4 hours later (Fig. 2). The dextrose–insulin infusion was continued in the intensive care unit.

The combined metabolic and respiratory acidosis subsequently improved, and 12 hours after his arrest his trachea was extubated. The serum potassium remained elevated and, in addition, his blood urea and creatinine began to increase and he was referred for dialysis; renal function subsequently recovered. Thirty-nine days later he was discharged home with no subjective change in cerebral function. He is, however, paraplegic (sensory level T_7). An NMR scan of his spine was normal.

Discussion

Duchenne muscular dystrophy is an X-linked recessively inherited disorder. It affects 30/100 000 live born males of whom one third have a negative family history. It involves striated, smooth and cardiac muscle. Clinically, it is manifest between the ages of 2 and 6 years by waddling gait, pseudohypertrophy of the calves and the demonstration of Gower's manoeuvre. The attainment of normal motor milestones may be delayed before the age of 2 years, and difficulty in keeping up with peers, especially with respect to jumping, hopping and running may be demonstrated. ECG changes, comparable with cardiomyopathy, may develop as the disease progresses.[1] There is progressive deterioration of respiratory function due to involvement of respiratory muscles and the development of kyphoscoliosis. Death is usually secondary to pneumonia or cardiac failure.

The condition is associated with many anaesthetic complications which have been recently summarised by Smith and Bush.[2] Cardiac complications occur at varying times during anaesthesia. Cardiac arrest during anaesthesia was the initial manifestation in a number of cases.[3–13] Most commonly, asystole,[4,6–10,12,13] or ventricular fibrillation[3,5] occurred at induction and, with the exception of one case, just after suxamethonium had been administered. The patient became asystolic 3 minutes after induction with halothane in the case described by Marks *et al.*;[4] no suxamethonium was given. Halothane was used for induction in all cases except two,[10,12] where cyclopropane was used. The patient described by Linter *et al.*[10] subsequently received halothane and suxamethonium, before cardiac arrest occurred. Two cases[12,14] developed asystole intraoperatively after induction of anaesthesia with halothane, but only one received suxamethonium.[12]

There have been three previously documented cases[15,16] where the patients recovered consciousness after operation and subsequently developed ventricular fibrillation or asystole. All of these patients received halothane as the sole anaesthetic agent and were known to have Duchenne' muscular dystrophy.

Cardiac complications during anaesthesia in these patients are usually attributed to two causes, either hyperkalaemia secondary to rhabdomyolysis[6,7–9,12] or malignant hyperthermia.[3,5,10,13,14,16] However, the distinction between the two conditions is not always clear since they share common clinical features, such as hyperkalaemia, metabolic acidosis, myoglobinuria and elevated creatine kinase.

Serum potassium was elevated in five cases,[3,8,13,14,16] normal in four[5,9–11] and not estimated in five.[4,6,7,12,15] Serum potassium ranged from 7.9–12.8 mmol/litre when it was elevated and thus accounted for the refractoriness of the arrhythmias encountered. There has been some discussion as to whether malignant hyperthermia is associated with Duchenne's muscular dystrophy. It is now thought by some that there is no association. This is evidenced by the fact that the Malignant Hyperpyrexia Investigation Unit in Leeds has never, in 1800 muscle biopsies, discovered an association between the two conditions (personal communication F.R. Ellis). However, of the patients described above, four[3,5,13,16] had confirmatory *in vitro* tests to establish the likelihood of malignant hyperthermia susceptibility. No test has been shown to be ideal[17] and some, for instance halothane and caffeine contracture tests, are more widely accepted than others, such as the Ca^{2+} uptake test used by Kelfer *et al.*[16] and Wang and Stanley.[13] Rosenberg has also shown malignant hyperthermia susceptibility in a Duchenne's patient.[18] The two conditions therefore may coexist, but considering the incidence of proven coexistence and the prevalence of each disease, it is likely that they occur as separate traits.

It is interesting to note that only two of the cases in which they did coexist displayed an elevated temperature at the time of cardiac arrest[5,16] and that the increase in each case was only minimal (37.5 and 38°C respectively).

Rosenberg described the classical presentation of malignant hyperthermia.[19] Several variants are known to occur; these include a delayed increase in temperature,[20–22] or none at all if early circulatory arrest occurs.[21] It has been shown that non-depolarising muscle relaxants and barbiturates can delay the onset of malignant hyperthermia in susceptible swine.[19] Muscular rigidity is said to be absent in 25–50% of people who develop the condition.[19,21] It is more likely to occur if suxamethonium is administered after the start of halothane.[22] Ellis stated that, 'for a realistic provisional diagnosis of malignant hyperpyrexia (MH) to be made, corroborative evidence of MH should be sought at the time of the episode—this includes measurement of blood-gas tensions and pH, and serum potassium and creatine kinase concentrations at the time and 12–24 hours later, and urinalysis for myoglobin in the 1st voided specimen.'[23] By these criteria, our case could well have been a malignant hyperthermia reaction. Halothane and caffeine contracture tests need to be performed before a final diagnosis can be made. If indeed our patient did have malignant hyperthermia, then it would be only the sixth case reported in the literature to date of its occurrence in conjunction with isoflurane anaesthesia.[24–28] Of the five previously reported, three patients had also received suxamethonium,[25–27] and only one of the remaining cases has as yet been confirmed by muscle biopsy.[28]

It is, however, more likely that our patient suffered acute rhabdomyolysis secondary to anaesthesia, with the causative agent most probably isoflurane. It has been shown that in normal patients, suxamethonium results in the release of creatine kinase and myoglobin from muscle cells and that this effect is potentiated by halothane.[2,21] Our case is, to our knowledge, the first documented patient with Duchenne's muscular dystrophy to have suffered a cardiac arrest after operation secondary to hyperkalaemia and to whom neither suxamethonium nor halothane had been administered, and the first in whom isoflurane has been implicated as the causative agent.

This case reinforces and illustrates several important points. Delayed motor milestones should be asked for directly when an anaesthetic history is taken in young boys. Cardiac arrest at induction of anaesthesia, especially in young boys, should alert one to the possibility of the event being an initial manifestation of Duchenne's muscular dystrophy. These patients require monitoring of ECG, pulse oximetry and temperature intra-operatively and in the postoperative period.

Suxamethonium and halothane should be avoided in patients with Duchenne's muscular dystrophy. These agents can trigger malignant hyperthermia, rhabdomyolysis and life-threatening arrhythmias in this group of patients. The present case demonstrates that isoflurane can also trigger rhabdomyolysis. It is also suggested that serum potassium should always be measured early on in cardiac arrest since it is a frequent and reversible cause of arrhythmias.

The present report also indicates that duration of resuscitation is not a good criterion for deciding when resuscitative efforts should cease, especially when dealing with a reversible cause of arrhythmias. Proper oxygenation and external cardiac compression have been shown to be compatible with no cerebral damage in prolonged resuscitation.[14]

This report raises the question, 'what is a safe anaesthetic for Duchenne's patients?'

Acknowledgments

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CASE REPORT

Obstetric anaesthesia in dystrophia myotonica

C. H. BLUMGART, D. G. HUGHES AND N. REDFERN

Summary

Two patients with dystrophia myotonica presented for urgent Caesarean section. Their per- and postoperative courses illustrate the anaesthetic problems posed by this disease. Respiratory difficulties are compounded by pregnancy and there is increased susceptibility to uterine haemorrhage. Choice of anaesthetic agent is discussed. Both had general anaesthetics; muscle relaxation was achieved with vecuronium.

Key words

Anaesthesia; obstetric.
Complications; dystrophia myotonica.

Dystrophia myotonica was first described by Steinert in 1909 and is the commonest of the myotonic syndromes; it is inherited as an autosomal dominant with a prevalence of 5 per 100 000.[1] The myotonia is characterised by an abnormal delay in relaxation of skeletal muscle after contraction. Electromyography is characteristic. Dystrophic elements predominate as the disease progresses, with weakness and wasting of the facial muscles, sternocleidomastoids, distal limb muscles and muscles of respiration. Arrhythmias, cardiomyopathy and diminished pulmonary reserve lead to death from cardiorespiratory failure in late middle age.

Pregnancy, although rare in these patients, is frequently complicated and may require anaesthetic assistance. We describe the anaesthetic management of two patients with dystrophia myotonica who required delivery by Caesarean section.

Case history

Patient 1

A 29-year-old woman, pregnant for the fifth time, who defaulted from the ward with a known 4th degree placenta praevia, presented at 34 weeks' gestation with a 300 ml antepartum haemorrhage in premature labour. Her dystrophia myotonica had been diagnosed by electromyography 9 years previously after the birth of her first child, who had congenital dystrophia myotonica.

She had undergone two previous Caesarean sections. The first was an unplanned procedure for failure to progress in labour due to cephalopelvic disproportion, and the second an elective operation. Anaesthesia on both occasions was induced with thiopentone and maintained with nitrous oxide, oxygen and halothane. Suxamethonium was used for neuromuscular blockade at the first Caesarean section, followed by alcuronium, which was successfully reversed with atropine and neostigmine. Suxamethonium was withheld on the second occasion and pancuronium administered. Neuromuscular blockade was not reversed and the patient allowed to recover spontaneously.

Her disease had progressed at this presentation; she was unable to do routine housework. Her ankles gave way when she climbed stairs, but she did not complain of a reduced exercise tolerance. Examination revealed the characteristic facies of dystrophia myotonica together with weakness and myotonia of her hands. The arterial blood pressure was 120/70 mmHg and pulse 78 beats/minute after initial resuscitation with 1000 ml compound sodium lactate. The haemoglobin was 10.4 g/dlitre. Coagulation studies, urea and electrolytes and blood glucose were within normal limits. An ECG showed sinus rhythm with a P-R interval of 0.2 seconds.

Arrangements were made for urgent Caesarean section.

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Ranitidine 150 mg was administered orally and 30 ml 0.3 M sodium citrate given immediately prior to transfer to the operating theatre. She was placed on a warming mattress with the operating table tilted to the left.

Etomidate 12 mg and vecuronium 6 mg were administered, after pre-oxygenation, with the application of cricoid pressure and intubation performed under excellent conditions after one minute. The ECG showed occasional ventricular ectopics during pre-oxygenation and at tracheal intubation she developed runs of multifocal ectopics that returned to sinus rhythm after 4 minutes.

Anaesthesia was maintained with nitrous oxide 50% in oxygen and enflurane 0.8%. ECG, blood pressure, central venous pressure, temperature and neuromuscular blockade were monitored. All intravenous fluids were warmed.

Syntocinon 10 IU and fentanyl 50 μg were administered after delivery. The placenta was partly adherent to the uterus and was manually removed with some difficulty. The uterus was atonic and did not respond to compression, a further 10 IU bolus of syntocinon or to an infusion of syntocinon. It was decided, due to continuing haemorrhage, to perform a hysterectomy. Estimated blood loss was in excess of 2 litres and she was transfused with 4 units of blood, 800 ml gelatin and 2 units of fresh frozen plasma. The patient was transferred to the intensive care unit for overnight artificial ventilation of her lungs.

A laparotomy was performed 8 hours later since the patient's girth had increased and she continued to require blood to maintain her central venous pressure and haematocrit. Anaesthesia was induced with fentanyl 100 μg, vecuronium 4 mg and maintained with nitrous oxide, oxygen and enflurane. A small bleeding artery in the right uterine pedicle was found and ligated. A further 2 units of blood, 4 units of fresh frozen plasma and 500 ml of colloid were given. Dopamine at 3 μg/kg/minute was started to boost a dwindling urine output.

She had a mild degree of pulmonary oedema on return to the intensive care unit, which responded to frusemide 10 mg. Sedation and analgesia were adequately provided by a fentanyl infusion at 100 μg/hour. She was weaned off the ventilator and her trachea extubated the next day.

The patient's ability to cough and clear her secretions was poor and despite vigorous physiotherapy, she developed a left lower lobe collapse and pneumonia with progressive hypoxia and hypercarbia that required re-intubation and ventilation 18 hours after extubation. Coliform organisms were cultured and antibiotic therapy commenced. By the sixth postoperative day, the patient was well enough for her trachea to be extubated. The remainder of her recovery was uneventful.

The baby was in extremely poor condition at delivery, with an Apgar score of 1 at 1 minute and 1 at 5 minutes. She remained hypotonic and required continued artificial ventilation with high inflation pressures for hyaline membrane disease. Further complications included dependence on inotropes and vasodilators, development of jaundice and a pneumothorax. The baby died on the fifth day. Postmortem examination revealed severe hyaline membrane disease and a small ventricular septal defect.

Patient 2

A 19-year-old primigravid patient presented at 38 weeks' gestation with spontaneous onset of labour and mild pre-eclampsia. At 21 weeks' gestation she had complained of weakness of her knees and ankles. Dystrophia myotonica was diagnosed on the basis of classical facial features and characteristic electromyography. Hydramnios had been noted at 28 weeks. She had no previous medical history and had never undergone general anaesthesia. She was in early labour at this presentation with an arterial blood pressure of 140/90 mmHg, gross pedal oedema and proteinuria. There was no evidence of weakness or myotonia. ECG, urea and electrolytes, haemoglobin and clotting studies were all within normal limits.

A lumbar epidural catheter was inserted and good analgesia provided with an infusion of bupivacaine 0.125% at 8 ml/hour. Ranitidine 150 mg orally was administered and 4 units of blood cross-matched. Despite 5 hours of augmentation with syntocinon, labour failed to progress and delivery by Caesarean section was decided upon.

Her circulation was preloaded with 400 ml plasma protein fraction and epidural blockade was extended to the level of T_5 with 24 ml bupivacaine, given in increments over 15 minutes. Sodium citrate 30 ml 0.3 M was administered orally and she was transferred to the operating table, which had a warming mattress and a left tilt. Oxygen was given by facemask. All intravenous fluids were warmed. ECG and blood pressure were monitored.

The mother complained of pain on the first skin incision and it was apparent that the epidural blockade was inadequate for surgery. A general anaesthetic was therefore administered. Anaesthesia was induced, after pre-oxygenation, with thiopentone 250 mg and vecuronium 6 mg. Cricoid pressure was applied and tracheal intubation achieved under excellent conditions at one minute. Anaesthesia was maintained with nitrous oxide 50% in oxygen and enflurane 0.8%. At delivery, syntocinon 10 IU was administered and an infusion of 80 IU given over one hour. Morphine 5 mg was given intravenously.

Measured blood loss was 1000 ml before the uterus contracted in response to syntocinon and uterine compression. Uterine atony led to a further 500 ml blood loss per vaginum at the end of surgery. The uterus responded well to bimanual compression and remained contracted. A total of 3 units of blood were transfused. Neuromuscular blockade was monitored and the last twitch in the train-of-four stimulation reappeared at 60 minutes. She still exhibited signs of partial blockade at 75 minutes and neostigmine 1.5 mg and glycopyrronium 0.3 mg were administered. Her tidal volume increased and her strength improved sufficiently to allow extubation and transfer to the recovery area.

Satisfactory analgesia was provided postoperatively by a patient-controlled syringe pump with morphine in 1-mg boluses with a lockout time of 8 minutes and no background infusion. The patient's postoperative course was uneventful.

The baby was meconium stained and hypotonic at delivery. The Apgar score was 1 at 1 minute and 5 at 5 minutes. Intubation and ventilation were required for 20 minutes before spontaneous respiration was established. She was monitored on the special care baby unit and remained hypotonic with poor feeding. A diagnosis of congenital dystrophia myotonica was made with a differential diagnosis of birth asphyxia. By day 9 she was demand feeding and well enough to be returned to her mother.

Discussion

These cases illustrate a number of the difficulties that face the anaesthetist who provides analgesia and anaesthesia for operative obstetric procedures in mothers with dystrophia myotonica. Respiratory involvement, as in our first patient, is common and progressive. There is weakness and fatiguability of the diaphragm, intercostals and accessory muscles of respiration. Pulmonary function tests are normal in the early stages, except for a reduction in the maximal expiratory pressure.[2] With progression, a restrictive pattern may develop with reduction in expiratory reserve volume, vital capacity, minute volume and maximal breathing capacity.

To compound the respiratory problems, there is increased sensitivity to the central nervous system effects of general anaesthetics, opioids and other sedative drugs.[3] Induction agents are known to have marked respiratory depressant effects, although thiopentone has been used uneventfully in many patients[4,5] and proved satisfactory in our second patient.

The risk of regurgitation with general anaesthesia for Caesarean section is compounded by laryngeal weakness, poor oesophageal motility and increased abdominal pressure associated with hydramnios. Reduction of gastric acidity, correct application of cricoid pressure and careful management of tracheal extubation are thus of particular importance. Intubation may be achieved using the induction agent alone, but we considered this choice of technique inadvisable for rapid sequence induction. Suxamethonium is contraindicated because it can cause generalised muscle contraction and make intubation and even ventilation impossible.[6] The response of patients with dystrophia myotonica to non-depolarising muscle relaxants is usually normal,[5] but increased sensitivity has been reported.[7,8] Atracurium has been recommended, because its predictably short duration of action may avoid the need for an anticholinesterase.[9-11] We used a rapid sequence technique of intravenous induction followed by vecuronium 0.1 mg/kg. Intubation in both cases was easily achieved at one minute after administration of the relaxant.

Inhalational agents are widely used for maintenance of anaesthesia, although the use of halothane may be contraindicated,[3] because of postoperative shivering. Precautions should be taken against losing body heat, such as use of a warming mattress, warm intravenous fluids and humidification of anaesthetic gases, since cold can precipitate myotonia. The patient's temperature should be monitored.

Neostigmine has been used successfully for reversal of neuromuscular blockade, although prolonged weakness due to incomplete reversal and depolarising block have been reported.[7,12] The usual signs of adequacy of recovery, eye opening, lifting the head, hand grip etc. may be interfered with by the disease process and should be interpreted in this context.[12]

The cardiac abnormalities seen in our first patient are due to dystrophic involvement of the conducting tissues, which result in varying degrees of heart block and arrhythmias.[13] Common ECG abnormalities include a prolonged P-R interval and a widened QRS complex. Many of the arrhythmias are intermittent.

Pregnancy is uncommon due to ovarian failure and is exceedingly rare in advanced disease. Should pregnancy occur, it may be accompanied by an exacerbation of the disease. This occurred in both our patients and may be due to the effects of progesterone on membrane potential.[14] Complications include spontaneous abortion, hydramnios, premature onset and poor progress of labour, which usually responds to augmentation with syntocinon.[15,16] The incidence of instrumental delivery is high, because of poor voluntary maternal assistance and an abnormal pattern of uterine contraction.[17,18] Such atonia may result in postpartum haemorrhage.

Epidural analgesia has been used successfully to provide pain relief for labour, and is the method of choice since opioids are contraindicated, because of increased sensitivity.[17] The choice between regional and general anaesthesia for operative delivery is less clear. Caesarean section under regional anaesthesia has been employed successfully,[19-22] but the risk of significant intra-operative haemorrhage must be considered. Such haemorrhage may be refractory to oxytocics, including ergometrine,[18] and may be so severe as to necessitate hysterectomy.[19]

Regional anaesthesia was contraindicated in our first case by the diagnosis of placenta praevia and a significant antepartum haemorrhage. In the second patient, as a functioning epidural was in place and operative delivery was not believed to be urgent, it was elected to perform the operation under epidural blockade. It was decided that supplementation with systemic analgesics would be unwise in view of the patient's underlying disease, when the blockade was found to be inadequate. General anaesthesia was considered the safe option.

Postoperative morbidity and mortality are usually due to respiratory problems. Dystrophia myotonica has been classified into four grades depending on the degree of disability,[2] and there is good correlation between the degrees of disability and the requirement for postoperative ventilatory support.[23] A reduction in maximum expiratory pressure decreases the ability to cough effectively and significant retention of secretions is the most common respiratory complication. Aspiration may occur at any time in the peri-operative period with resulting atelectasis and bronchopneumonia. Treatment of respiratory failure with prolonged ventilation and physiotherapy are frequently required in significant disease.

Postoperative analgesia is probably best achieved in spontaneously breathing patients by regional blockade. Systemic opioids should be administered with caution and the patient observed in a high dependency area. We used patient-controlled analgesia in our second case and found it to be satisfactory.

The baby born to a mother with dystrophia myotonica has a 50% chance of being affected and is characteristically hypotonic at birth. There may be problems with respiration and feeding is poor. Death due to pneumonia is common. Birth of a hypotonic baby may be the first indication of the disease in the mother and may be incorrectly ascribed to perinatal asphyxia especially if there are associated respiratory problems.[24,25]

Best results in the provision of anaesthesia for Caesarean section in a patient with dystrophia myotonica are obtained if the diagnosis is known and a plan of action formulated. Assessment of the severity of the disease on the basis of functional disability, response to previous anaesthetics remembering that the disease is progressive, and physical examination gives a guide to the likely requirement for postoperative support. Investigations should include ECG, chest X ray, haemoglobin, urea and electrolytes, blood glucose and pulmonary function tests. Cross-matched blood should be immediately available and bleeding problems anticipated. Caesarean section should only be carried out in a centre which has facilities for the postoperative care of the mother and intensive resuscitation and care of the baby.

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CASE REPORT

'Leopard' syndrome

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Summary

'Leopard' syndrome is a rare inherited disorder associated with a high prevalence of cardiac abnormalities. General anaesthesia for dental treatment in a patient who had cardiomyopathy and bizarre electrocardiographic abnormalities associated with this syndrome is described. A thorough cardiac assessment is advised in a patient with multiple lentigines, although no clinical symptoms or signs may be found. Even if no cardiac abnormality is found before it is better to re-assess the patient, since abnormalities may develop later. The assessment should be repeated if any abnormality was detected before but without clinical significance, since the disease is progressive and may progress more rapidly in some patients than in others.

Key words

Heart; cardiomyopathy.

The Leopard syndrome, an acronym which serves as a mnemonic device for remembering the classical features of this disorder, consists of L, lentigines (multiple); E, electrocardiographic conduction abnormalities; O, ocular hypertelorism; P, pulmonary stenosis; A, abnormal genitalia; R, retardation of growth, and D, deafness (sensorineural).[1]

There are no reports in the anaesthetic literature of patients with this rare syndrome.

Case history

The patient was a 15-year-old male child, the youngest of three siblings. He had been a full term normal delivery with a birth weight of 2.9 kg. He had suffered from neonatal jaundice that required phototherapy, and from repeated attacks of chest infection. However, exercise tolerance was satisfactory. His physical growth was retarded; his height was 131 cm and weight 27 kg. He was also retarded mentally. He had a dark complexion with multiple lentigines on his back (Fig. 1). Hypertelorism and a wide nose were other prominent features. There was a single transverse palmar crease and normal genitalia.

Cardiovascular examination revealed no cyanosis and no finger or toe clubbing. All peripheral pulses were palpable and were equal bilaterally. There was no delay between the radial and femoral pulses. The apex of the heart was palpable in the 5th intercostal space at the mid-clavicular line. A systolic thrill was felt over the left sternal border, and a grade 4/6 harsh ejection systolic murmur was heard all over the precordium; this was loudest over the left sternal border and radiated to the left axilla and to both sides of the neck. The murmur was compatible with subaortic stenosis. Breath sounds were equal on both sides and no adventitious sounds were noted. Neither the liver nor spleen was palpable. Chest X ray revealed a heart shadow within normal limits and clear lung fields.

Electrocardiography (ECG) revealed bizarre conduction patterns (Fig. 2). The rhythm was sinus with a frontal QRS axis of $-14°$, and a rate of 107 beats/minute. There were Q waves in leads I, II, III, aVF and V_4 to V_6; the PR interval was 150 msec, QRS duration 88 msec, QT interval 367 msec, and QTC interval 485 msec. The ECG findings were compatible with a sinus tachycardia, ventricular premature contractions, inferior myocardial infarction, anterior myocardial infarction, lateral myocardial infarction and possible biventricular hypertrophy.

Echocardiography, cardiac catheterisation and Holter monitoring were carried out. Echocardiographic and catheterisation findings were compatible with hypertrophic cardiomyopathy with a left ventricular outflow tract gradient of 60 mmHg. Left ventricular angiographic studies indicated outflow tract obstruction due to muscle bulge from the left ventricular septum. There was no mitral regurgitation. Holter monitoring showed sinus rhythm with occasional isolated ventricular ectopic beats.

Holter monitoring of the heart rhythm was started preoperatively and continued intra-operatively and postoperatively for 24 hours. Premedication was diazepam syrup 6

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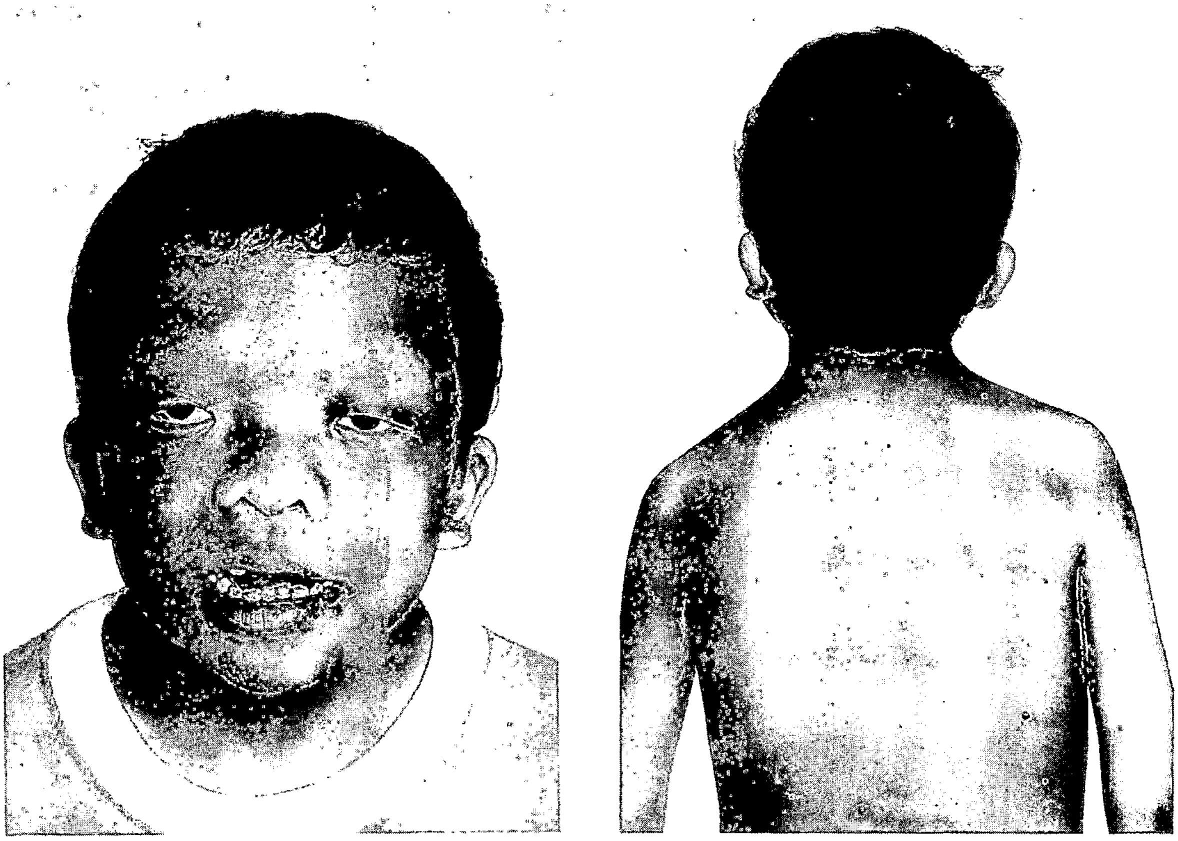

Fig. 1. Patient's face showing ocular hypertelorism and multiple lentigines, and back, showing multiple lentigines.

mg given 1.5 hours before operation. Antibiotic cover with crystalline penicillin was administered. Blood pressure, pulse (rate and wave) and ECG were monitored and recorded in the anaesthetic room. Inhalational induction was performed with nitrous oxide, oxygen and halothane. Suxamethonium was given to paralyse the patient, and his lungs were ventilated with oxygen and halothane. The trachea was intubated with a lubricated noncuffed nasotracheal tube and the throat was packed gently. Anaesthesia was maintained with oxygen 2 litres/minute and nitrous oxide 4 litres/minute with halothane 1.5% via a Bain system until spontaneous breathing was re-established, when the minute volume was increased to 9 litres/minute. The patient's cardiac rhythm altered to ventricular bigeminy with the onset of spontaneous breathing. Blood pressure remained stable. No drug treatment was instituted but ventilation was assisted using 100% oxygen and halothane 1.5% until the patient was placed on the operating table.

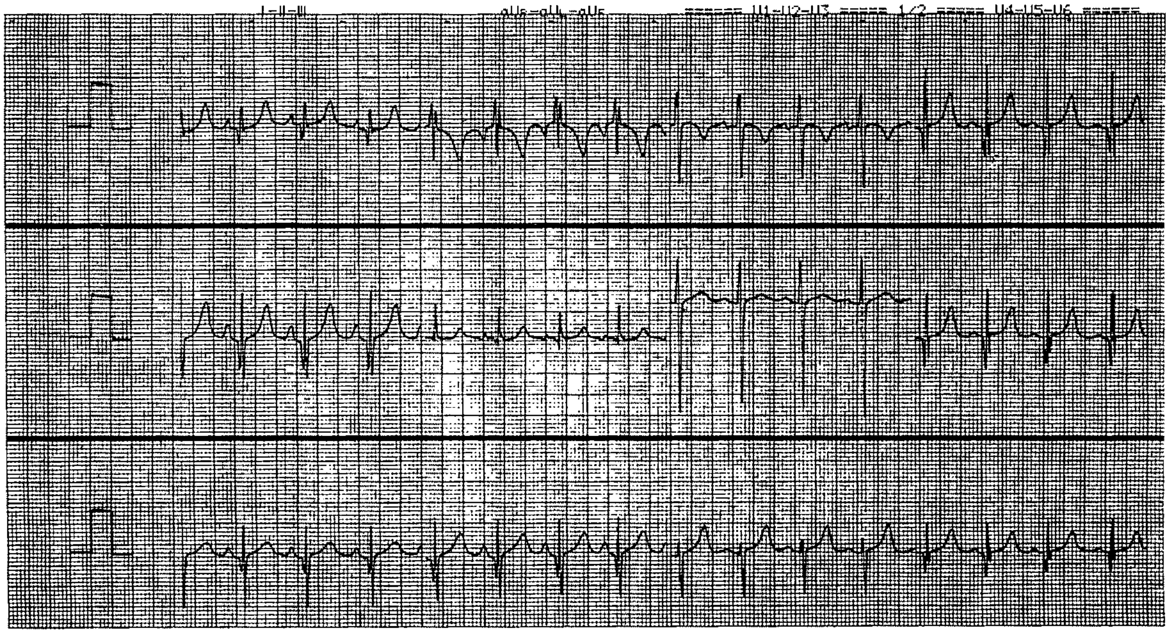

Fig. 2. Electrocardiograph showing bizarre abnormalities (see text).

Blood pressure, heart rate, oxygen saturation and electrocardiogram were monitored, nitrous oxide was re-introduced and enflurane was administered instead of halothane. Fentanyl 250 μg was given intravenously before the start of surgery and the ectopic rhythm disappeared spontaneously after about 8 minutes. Examination and dental treatment were carried out uneventfully.

Discussion

The spotted appearance presented by these patients led Gorlin[1] to introduce the name 'Leopard syndrome' as a mnemonic in order to recall the various features of this syndrome. The patient reported here had multiple lentigines, electrocardiographic abnormalities, ocular hypertelorism, subaortic stenosis (hypertrophic cardiomyopathy), and retardation of growth. However there was no abnormality of genitalia and no deafness.

A single mutant gene with high penetrance and marked variation in expression is believed to produce the defects in this syndrome. It has an autosomal dominant mode of inheritance.[1,2] No other member of this family had any clinical features of the syndrome.

The cardiac lesion in this patient was hypertrophic cardiomyopathy. Similar reports of cardiomyopathy associated with this syndrome have appeared before. In our case echocardiography and angiography revealed asymmetrical septal thickening that caused a muscle bulge into the left ventricle and left ventricular outflow obstruction. Similar left-sided obstructive cardiomyopathy associated with multiple lentigines has been described before.[2–5] Three cases in which the main feature was right ventricular hypertrophy with bulging septal muscle and right ventricular outflow obstruction have been reported.[6] Cardiac catheterisation revealed only obstructive cardiomyopathy that involved the left side in our patient, but electrocardiography showed evidence of biventricular hypertrophy.

The possibility of cardiomyopathy should be considered in any patient with lentigo and heart murmurs,[6] even if previous examination has failed to reveal any cardiac involvement. The association of multiple lentigines and cardiomyopathy may be the result of a genetically-triggered abnormality of neural crest elements found both in skin and in heart.[2] The onset is usually in early childhood; subsequent progression may be mild and slow or severe and florid.[5] In our case the cardiac lesion appears to have developed slowly, since a heart murmur had been diagnosed at the age of 1 year, and the patient had lived to the age of 15 years without signs of decompensation.

The systolic murmur detected in our patient may have resulted from subaortic stenosis as a result of hypertrophic cardiomyopathy. The most commonly described lesion in this syndrome is pulmonary stenosis.[1,7–13] Typical valvular stenosis[1,7,13] and pulmonary valvular dysplasia (three distinct cusps and no commissural fusion) have been described.[7,14,15] The latter type is differentiated by the presence of a pulmonary ejection murmur without an associated ejection click. Subaortic stenosis,[4] subpulmonary stenosis,[6] and occasionally mitral valve involvement[10] have been described also. A left atrial myxoma associated with lentiginosis[16] has been described. Both myxomata and lentigines arise from an anomaly of the neural crest. Patients with lentiginosis and unexplained systemic arterial obstruction warrant cardiological assessment, especially echocardiography, to exclude the presence of a myxoma.

Electrocardiographic abnormalities occur frequently in this syndrome.[1,2,4,6,8,9,11,17–24] The changes recorded in this patient were bizarre; they were compatible with old anterior, lateral and inferior myocardial infarction and possible biventricular hypertrophy. Similar electrocardiographic abnormalities such as right[6] or left[2] or biventricular enlargement,[4,6] infarction patterns, ischaemic patterns of ST and T waves,[4,17] and a combination,[25] have been reported. The widespread QRS abnormalities exhibited by this patient probably reflect abnormal ventricular depolarisation as a result of the cardiomyopathic process.

A common ECG change in this syndrome is left axis deviation, often to between −60° and −120°.[1,4,7,17] In our patient the frontal QRS axis was −14°. Conduction abnormalities have been reported frequently and are due primarily to combinations of blocks in the bundle branch system.[18] Prolonged PR intervals,[1,19] left anterior[18,22] or left posterior hemiblock,[18] bundle branch block[1,17,18] or a combination of these[18] with complete heart block have been reported. No such conduction abnormalities were detected in this patient, but occasional isolated ventricular ectopic beats were recorded during Holter monitoring. This has not been reported before in the literature about the Leopard syndrome. The ECG abnormalities may be asymptomatic[18] and well tolerated,[19] as in our case, or sufficiently severe to provoke sudden death.[24] The conduction impairment is said to be progressive and to develop gradually.[18] Some patients are reported to have normal ECG tracings.[1,2,26,27]

The anaesthetic management of patients with hypertrophic cardiomyopathy requires special consideration to be given to factors that may produce changes in intravascular volume, ventricular contractility and transmural distending pressure of the outflow tract.[28] Volume depletion may occur during anaesthesia because of pre-operative starvation, and hypotension may result from administration of anaesthetic drugs. Tachycardia may be deleterious as it decreases diastolic filling time and stroke volume. Increased myocardial contractility increases turbulent flow across the outflow tract and enhances outflow tract obstruction. In this patient, anticholinergic premedication was avoided and midazolam was given as premedication to reduce anxiety. Intravenous induction may produce less anxiety than inhalational induction, but as this patient was mentally retarded and uncooperative, inhalational induction was carried out. Induction with enflurane or isoflurane could have been difficult because of coughing and struggling; consequently, halothane was used. Some authorities recommend avoidance of halothane to avoid bradycardia and the resultant drop in cardiac output;[28] others recommend its use with adequate volume replacement because it decreases the force of ventricular contraction, and slows heart rate, tending to minimise the severity of obstruction.[29]

Morphine was avoided in our patient as it may cause venodilatation and hypovolaemia. Fentanyl produces minimal vascular side effects and a slight decrease in heart rate. Enflurane[30] was used instead of halothane in the operating theatre as the latter is reported to produce a high incidence of arrhythmias during oral surgery,[31] especially in Chinese.[32] Deepening of anaesthesia and introduction of enflurane resulted in the disappearance of the arrhythmia. Transmural distending pressure may be decreased by hypotension secondary to anaesthetic drugs, hypovolaemia or positive pressure ventilation; in this case, there was no significant decrease in blood pressure, blood loss was minimal and the patient breathed spontaneously. Beta-blockers are said to reduce the outflow obstruction, but heart rate was maintained within normal limits in our patient and beta-blockers were not used. Local anaesthetic solutions with adrenaline were avoided to prevent tachycardia.

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CASE REPORT

Acute infective airway obstruction associated with subglottic stenosis

J. J. PHILLIPS AND A. J. SANSOME

Summary

Pre-existing subglottic stenosis in a 22-month-old child with laryngotracheobronchitis resulted in failure to intubate the trachea on the intensive therapy unit. Tracheostomy was necessary in the operating theatre to secure the airway. The implications for safe management are discussed.

Key words

Intubation, tracheal; tracheostomy.
Complications; tracheal stenosis.

The management of acute infective airway obstruction in children has changed considerably over the last 20 years. The safety and efficacy of nasotracheal intubation in these children has been realised, and as experience with its use has increased, tracheostomy has become much less common.

Children with suspected acute epiglottitis, or with laryngotracheobronchitis which is not responding to treatment, are usually transferred to the operating theatre. Examination under anaesthesia and tracheal intubation are performed by an experienced anaesthetist, with an ear, nose and throat surgeon in attendance in case tracheostomy is necessary. However, some reports have questioned the need to have a surgeon standing by, and suggested that tracheal intubation may be performed safely in the intensive therapy unit (ITU) rather than the operating theatre.[1,2].

The following case report demonstrates that this approach is not without risk.

Case history

A 22-month-old child was admitted with a low grade pyrexia, inspiratory and expiratory stridor and a barking cough after a 5-day history of upper respiratory tract infection. She was tachypnoeic (35 breaths/minute), with nasal flaring, suprasternal and subcostal recession, and she had a sinus tachycardia of 140 beats/minute. A diagnosis of croup was made and she was treated with steam inhalation. Her condition gradually deteriorated over the next 4 hours, with increasing stridor; the suprasternal and subcostal recession became more marked and she became cyanosed. An ear, nose and throat surgeon was contacted and the patient was transferred to ITU for examination under anaesthesia and nasotracheal intubation.

Monitoring of the electrocardiograph, and peripheral oxygen saturation by pulse oximetry, were instituted. Inhalational induction of anaesthesia was achieved with halothane in oxygen. Venous access was secured, 10 μg/kg atropine administered, and direct laryngoscopy undertaken under deep halothane anaesthesia. The larynx was examined and the cords were noted to be slightly oedematous. The supraglottic region was normal. An attempt was made to pass a 3.5-mm internal diameter tracheal tube but resistance just beyond the cords prevented intubation. Neither 3.0-mm nor 2.5-mm tracheal tubes could be passed beyond the obstruction. It was difficult to maintain arterial oxygen saturation above 85% despite assisted ventilation with 100% oxygen and during the final attempt at intubation the saturation decreased briefly to 60%.

It was considered that tracheostomy in the controlled conditions of the operating theatre would provide the safest solution, but since the transfer of a patient with a precarious airway would be dangerous, she was allowed to wake up.

Inhalational induction of anaesthesia was repeated in the operating theatre and a routine tracheostomy performed under assisted spontaneous ventilation. Direct laryngoscopy was performed after the tracheostomy had been established. There appeared to be a circumferential subglottic

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stricture, and therefore a diagnosis was made of laryngotracheitis with a pre-existing subglottic stenosis.

The laryngotracheitis settled satisfactorily, and 3 weeks after the initial surgery a further direct laryngoscopy was performed which confirmed the diagnosis of subglottic stenosis. The child continues to depend on her tracheostomy but is otherwise completely well. Definitive surgery is awaited.

Discussion

This child had a low Apgar score at birth, and was believed to have aspirated meconium. The trachea was intubated for 7 minutes. It is possible that this episode was the cause of subglottic stenosis, but it is more likely that the stenosis is congenital in origin. Congenital subglottic stenosis, which has been estimated to have an incidence of one in a thousand, is defined as an airway that is more than one millimetre smaller in diameter than that predicted by age, and invariably lies at the level of the cricoid ring.[3] Only 6% of children admitted to hospital with croup require airway support,[1,4] and therefore the probability of tracheal intubation being required in a child with an acute infective airway obstruction and an associated congenital laryngeal narrowing is small. However, the need for airway support is likely to be increased when the combination co-exists. One case in which croup and a suspected subglottic stenosis coincided has been reported.[1] Intubation with a tracheal tube of diameter 0.5–1.0 mm smaller than that predicted has been recommended.[5,6] Pre-existing subglottic stenosis may necessitate the use of a tube which is at least 1.5–2.0 mm smaller.

Tracheostomy may be a life-saving procedure if tracheal intubation proves impossible. In the hands of an experienced surgeon it is safer than cricothyroid puncture because the anatomical landmarks are poorly defined in children. However, emergency tracheostomy in children is not without its dangers; bilateral tension pneumothoraces, exanguinating haemorrhage, cannulation of the oesophagus and internal carotid artery, and transection of the trachea have been reported.[7]

We recommend that children with acute infective airway obstruction, who need an examination under anaesthesia, should be transferred to the operating theatre where direct laryngoscopy and intubation can be carried out by an experienced anaesthetist in the presence of an ear, nose and throat surgeon. Tracheostomy can be undertaken safely if necessary. A protocol that sets out the management of such children should be agreed between the departments of anaesthesia, paediatrics and ear, nose and throat surgery, and be brought to the attention of all those staff likely to be involved.

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Anaesthesia, 1990, Volume 45, pages 36–39

APPARATUS

The Keeler Pulsair air impulse tonometer

Comparison with the Perkins hand-held applanation tonometer for peri-operative measurement of intra-ocular pressure

S. R. W. BRICKER, J. N. McGALLIARD AND S. M. MOSTAFA

Summary

The Keeler Pulsair is a noncontact tonometer which can be used by those without specialist ophthalmic training. The instrument was compared, in a series of 30 patients in whom a total of 150 readings were taken, in respect of accuracy, ease and speed of use, and acceptability to patients, with the Perkins hand-held applanation tonometer. There was good correlation between measurements obtained with the two instruments: $r = 0.92$, $(p < 0.001)$; *the Pulsair was described as easy to use in 87% of subjects, and no patient found the procedure unpleasant. The median times taken for Pulsair measurements were 7 (range 4–14) seconds for a single reading in conscious patients, and 11 (range 4–29) seconds for four readings in anaesthetised patients. These times were significantly quicker than those recorded with the Perkins tonometer which were 83 (range 66–138) seconds and 20 (range 8–45) seconds respectively* $(p < 0.001)$. *We conclude that the Pulsair is suitable for use by those who are not ophthalmologists for the rapid measurement of intra-ocular pressure changes during anaesthesia.*

Key words

Equipment; tonometry.
Eye; intra-ocular pressure.

The Keeler Pulsair air impulse tonometer was designed to overcome some of the disadvantages of conventional contact tonometry and measures intra-ocular pressure (IOP) without touching the cornea. The instrument uses automated focusing and initiation mechanisms, which appear to make it suitable for use by those who are not ophthalmologists, and, since its design allows a competent user to take several measurements within a matter of seconds, it may be particularly useful for the peri-operative measurement of changes in IOP.

One of the instruments regularly used for measuring IOP during anaesthesia is the Perkins hand-held applanation tonometer. This device uses conventional contact applanation tonometry, and is considered to reflect accurately the IOP as measured by the Goldmann tonometer. However, the Perkins tonometer requires considerable training in use and interpretation and is therefore not suitable for use by nonophthalmologists.

This study aimed to determine the suitability of the Pulsair for the peri-operative measurement of IOP by anaesthetists, and to compare its ease of use and acceptability to patients with the Perkins tonometer.

Description of the instrument

The Pulsair is mains powered. The console measures 355 × 305 × 205 mm, and weighs 9 kg. A handpiece attached to the console measures 265 × 115 × 40 mm and weighs 1 kg (Fig. 1). Measurements are made by taking the handpiece to the eye of the patient until a focused and centred target image indicates the correct position. No chin or head rest is needed. The device at this point activates automatically and displays the IOP rounded to the nearest number in mmHg on the digital readout. The instrument measures IOP in the range 0 to 55 mmHg. The handpiece incorporates correction buttons for cases in which the IOP is greater than 30 mmHg, or in which the cornea is scarred or irregular. A demonstration button allows the operator to demonstrate the pulse of air to the patient on, for example, the back of a hand, before measurements are taken.

Principle of measurement

The Pulsair applies a ramped air impulse to the eye which is measured by a pressure transducer in the handpiece at the

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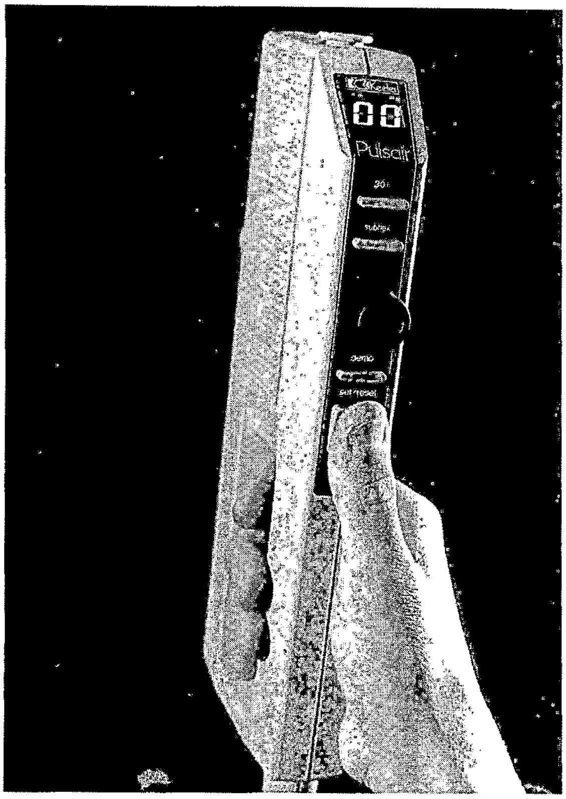

Fig. 1. The 'Pulsair' handpiece.

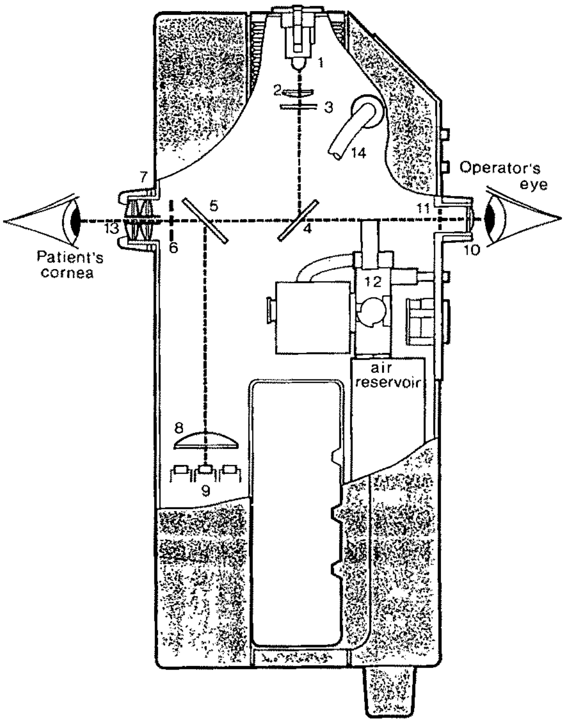

Fig. 2. Schematic diagram of handpiece: 1 bulb; 2 condenser lens; 3 filter; 4 beam splitter (1); 5 beam splitter (2); 6 mask; 7 objective lens set; 8 'contrast' lens; 9 photodetectors; 10 viewing lens; 11 image; 12 air reservoir valve; 13 air impulse tube; 14 internal pressure transducer.

time of the applanation event. The IOP at that moment has been related to the impulse pressure by calibration studies which have confirmed a close and statistically significant correlation between the Pulsair and conventional Goldmann contact applanation tonometry.[1] The correct alignment and focusing of the instrument is ensured by an optical system which uses a split and reflected light beam and an array of photodetectors located in the handpiece. The air impulse is initiated automatically and the photodetectors then detect the applanation event, when this optical system confirms precisely correct positioning.

This system is shown in more detail in Figure 2. Light from a bulb (1) passes through a condenser lens (2), a filter (3) and onto a beam splitter (4). Part of this light is then projected forward through a second beam splitter (5) and a mask (6). This mask produces the target image which is projected by a set of objective lenses (7) onto the patient's cornea. The cornea reflects the image back through the optical system. Part of this reflected light is diverted by the second beam splitter via a 'contrast' lens (8) onto a set of three photodetectors (9). Part of the light also passes through both beam splitters and through the viewing lens (10) to form an image (11) which the operator uses for alignment. The image of the corneal reflex will fall on the photodetectors so that more light falls on the outer diodes than on the centre one, when the handpiece is correctly aligned to the patient's cornea in respect of distance as well as horizontal and vertical alignment. This signal of correct alignment opens a valve (12) on the air reservoir, and allows an air pulse to be piped forward to the patient's eye via the air impulse tube (13). This pulse creates an applanation event on the patient's cornea, and by flattening it changes the characteristics of the corneal reflex such that more light now falls on the centre diode than on the sum of the outer two. At this point an internal transducer (14) which is connected directly to the pneumatic system samples the pressure pulse and immediately displays the result on the digital readout. The time taken from correct alignment to display is in the order of msec.

Methods

The study was approved by the District Medical Ethics committee and informed written consent was obtained in each case. Thirty consecutive patients due to have IOP measured by an ophthalmologist (J.N.McG.) using a Perkins applanation tonometer as part of their general ophthalmological examination before surgery agreed to allow one of the anaesthetists (S.R.W.B.) to precede this with a measurement taken by the Pulsair. Both measurements were timed to the nearest second by an independent observer. Timing started with each measurement as soon as the operator's hand first touched the patient's forehead. This included, in the case of the Perkins tonometer, the instillation of local anaesthetic eye drops (oxybuprocaine, 'Benoxinate' 0.4%), and fluoroscein from a dye-impregnated paper strip. The operators graded the procedure as easy, difficult or impossible. The acceptability of the methods was assessed by asking patients simply if either had been unpleasant and whether they would have any preference on a subsequent occasion.

Subjects also agreed to further measurements which were taken by the same operators after induction of anaesthesia. A single reading with the Perkins tonometer was compared with the mean of four consecutive readings (considered as one measurement in time) with the Pulsair on each of four occasions: one minute after induction of anaesthesia with thiopentone 4 mg/kg, one minute after suxamethonium 1 mg/kg and one and 5 minutes after tracheal intubation. Measurements were timed as before by an observer who also recorded the multiple Pulsair readings, and ease of determination was graded as previously.

Both instruments were calibrated by the manufacturers before the study. A display accuracy of ±1 mmHg was quoted for the Pulsair, and in the case of the Perkins tonometer, readings at the zero, 2-g and 5-g positions on the scale were quoted as correct within 100 μg, or 3% of the scale reading (whichever was the greater) when standard weights were applied along the axis of the prism at the working position.

Data were analysed by means of the Mann–Whitney *U* test and linear regression analysis as appropriate. Results were considered to be statistically significant when $p < 0.05$.

Results

The demographic characteristics of the patients are shown in Table 1. Both methods of measurement proved acceptable to patients: all of whom said that they would submit to either procedure again. Eleven out of 30 patients expressed a preference for the Pulsair, and two out of 30 preferred the Perkins tonometer.

The Perkins tonometer in conscious patients was significantly slower to use (Table 2), partly because of the need to anaesthetise the cornea. The median time with the Perkins was 83 (range 66–138) seconds, and with the Pulsair 7 (range 4–14) seconds ($p < 0.001$). Measurements in unconscious patients were also significantly quicker using the Pulsair: it was usually possible to take four IOP readings (median time 11, range 4–29 seconds), in less than the time taken to make a single measurement with the Perkins tonometer (median time 20, range 8–45 seconds) ($p < 0.001$).

The measurement of IOP using the Pulsair was described as 'easy' in over 85% of cases (26 out of 30), and in no patient was it impossible to obtain a reading. However, it was not possible to obtain a measurement using the Perkins tonometer on three occasions. There was good correlation between measurements taken using the two methods: $r = 0.92$; SEM 0.013; slope 0.91 (SD 0.06); intercept 1.52 (SD 0.86); ($p < 0.001$) (Fig. 3).

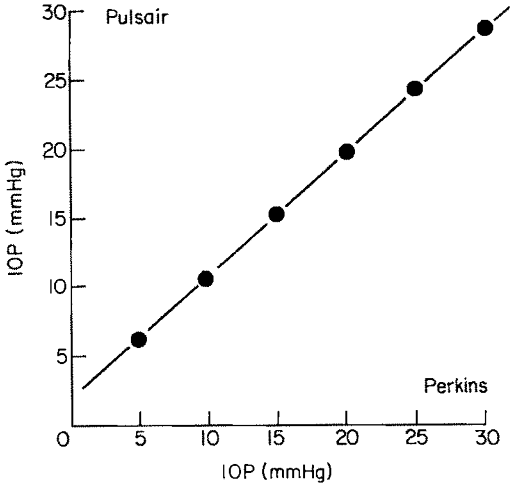

Fig. 3. Regression diagram from equation $y = a+bx$ relating IOP measurements made with the Pulsair and Perkins applanation tonometers. $r = 0.92$; $y = 1.52+0.91\,x$; $n = 150$.

Discussion

Intra-ocular pressure changes during anaesthesia are of continuing interest to anaesthetists, who hitherto have had to enlist the assistance of ophthalmologists to carry out studies. The time taken to perform a measurement with the Perkins tonometer, as the present investigation confirms, can militate against the monitoring of rapidly occurring pressure changes. The Pulsair, in contrast, allows several measurements to be taken within seconds by an operator who needs no ophthalmological training. The instrument is simple to use after a minimal period of familiarisation. The Pulsair measures automatically once positioning is achieved: no reading can be obtained unless alignment with and distance from the cornea are correct. To that extent the tonometer is operator independent; there is no interpretative element to the reading. The instrument never touches the eye thereby minimising the risk of corneal contamination, damage or infection. The accuracy of the Pulsair compares well with the Goldmann applanation tonometer,[1] traditionally regarded as the gold standard for IOP measurements. Contact tonometry has the disadvantage that by expressing aqueous humour from the anterior chamber of the eye during measurement it may make subsequent readings artificially low.[2] For this reason we measured IOP with the Pulsair before the Perkins tonometer and were able to demonstrate good correlation between the readings ($p < 0.001$).

The Pulsair was acceptable to all the patients tested, but in this respect it appears to offer no significant advantage over conventional tonometric methods. We did not consider that the overall preference by patients for the Pulsair was clinically significant: some described the instillation of local anaesthetic eye drops before measurement with the Perkins as mildly uncomfortable, but otherwise found the procedure innocuous. All subjects said that they would submit to either procedure again. The Pulsair can be used in either the sitting or supine positions, which may make it a more convenient method for both patient and operator in outpatients. All the patients in the present study were

Table 1. Demographic data. Values are expressed as mean (SD).

	Male	Female	Total	Age (years)	Weight (kg)
Patients	19	11	30	54 (19)	74 (13)
Males	19	—	19	49 (21)	79 (12)
Females	11	—	11	63 (11)	65 (10)

Table 2. Time (seconds) to measure IOP. Values expressed as median (range).

	Measurements taken in conscious patients ($n=30$)	Measurements taken in anaesthetised patients ($n=120$)
Perkins	83 (66–138)	20 (8–25) (single reading)
Pulsair	7 (4–14)*	11 (4–29)* (four readings)

*$p<0.001$

examined supine, and it should be noted that the Pulsair may be marginally more difficult to use in this position, particularly if the operator is not tall. The handpiece is relatively bulky and has to be aligned perfectly in relation to the cornea. This alignment is more difficult to achieve if the operator is forced to stretch over the patient. The use of a platform or adjustable table does however minimise the problem.

Difficulties were encountered with some of the readings in four patients. The eye was directed persistently downwards in one anaesthetised patient, which made centred alignment difficult to achieve, as did small, deep-set eyes, or prominent noses in a further two subjects. These anatomical features posed equal difficulties for the operator using the Perkins tonometer. Excessive lacrimation made focusing troublesome in the remaining patient; a problem which also made the Perkins tonometer difficult, and on some occasions, impossible to use. Nevertheless, four readings were obtained with the Pulsair tonometer, within 30 seconds in every case. The manufacturers recommend that the mean of four consecutive readings should be taken. This slows the speed of measurement were the operator to pause to record each value. It should be relatively simple, since the instrument is electronically operated, to equip the Pulsair with a printer which could record IOP measurements as they were taken.

This study comprised a simple clinical evaluation of the Keeler Pulsair from the point of view of the nonspecialist, and has made no attempt to evaluate its suitability for routine use by ophthalmologists. However, we conclude that for anaesthetists who investigate rapid intra-ocular pressure changes the instrument is both simple to use and accurate, and under these circumstances represents a significant advance over conventional tonometers.

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Forum

Effect of metoprolol and diazepam on pre-operative anxiety

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Summary

A double-blind study of 98 patients who underwent elective hysterectomy or orthopaedic surgery was conducted to evaluate the effect of metoprolol or placebo combined with diazepam given 1–3 hours before surgery. Evaluation was by anaesthetists and by visual analogue scoring by the patients. The anaesthetists found that patients who received metoprolol were significantly less anxious ($p < 0.005$) and better sedated ($p < 0.001$) before induction of anaesthesia. The patients who received metoprolol found themselves more calm compared with placebo patients. Arterial blood pressure and heart rate were reduced by metoprolol compared to placebo. Metoprolol may be a valuable drug for premedication.

Key words

Premedication; diazepam.
Sympathetic nervous system; beta-adrenergic antagonist, metoprolol.

The primary aims of premedication are to prevent or reduce the side effects of anaesthetic agents, relieve anxiety and produce sedation before anaesthesia.[1–6] Anxiety influences most other factors that concern premedication, so relief of anxiety is of major importance,[4–6] but the selection of the most appropriate drug is still a matter of debate. Benzodiazepines have found wide application due to their sedative and anxiolytic properties,[4,5,7–9] although some studies found little difference in the effect compared to placebo.[7,9] Several studies have shown beta-adrenergic blockade to be effective in reducing tremor, stress and anxiety under a variety of circumstances.[10–13] Recently we found that plasma catecholamines and anxiety were reduced when metoprolol was given for premedication[14] and others have shown that beta-blockade reduces arrhythmias during anaesthesia.[15–19]

The present double-blind trial was carried out to evaluate the effectiveness of pre-operative beta-adrenergic blockade together with diazepam, compared to diazepam alone, as premedication before anaesthesia.

Methods

One hundred patients (ASA grade 1 or 2) scheduled for elective hysterectomy or lower extremity orthopaedic surgery were randomly allocated in a double-blind fashion into two groups. Age, sex, height, body weight, arterial blood pressure and heart rate, together with details of current medication were recorded for each patient. All patients gave informed consent and the study was approved by the local ethics committee. Two patients had their operation cancelled, which left 98 patients to be studied.

Premedication was administered orally 1–3 hours before surgery. The patients received either metoprolol 100 mg or identical placebo tablets together with diazepam 15 mg. Evaluations were carried out in the ward before premedication and in the anaesthetic room before induction of anaesthesia. The effects of the drugs were assessed by the anaesthetist and the patient's marking on visual analogue scales (VAS).

Assessment by the anaesthetist. Anxiety and sedation together with the presence or absence of nausea and dizziness were evaluated by the anaesthetist using a modification of a method originally described by Dundee *et al.*[3–5] Cardiovascular variables were measured after the evaluations. The degree of sedation was graded as good (2 points), fair (1 point), slight or nil (0 point). Good sedation was regarded as present if a patient fell asleep when undisturbed and fair if they were drowsy but kept their eyes open. The degree of anxiety, after assessing and questioning the patient, was graded as nil, slight, moderate or marked before and after premedication. Relief or aggravation of anxiety, if any, was noted and scored accordingly, good (3 points), fair (2 points), slight (1 point) or nil (0 point). Dizziness and nausea were graded as present (-1 point) or absent. All assessments in each ward were performed by the same anaesthetist.

Assessment by patients. In addition, the patients were asked to rate their perceived anxiety, sleepiness, depression, relaxation and general status on a 10-cm horizontal visual analogue scale. The limits of the scales were: sleepiness, wide awake—extremely sleepy; anxiety, totally calm—extremely anxious; depression, not depressed at all—extremely depressed; relaxation, very relaxed—extremely tense; general feeling, never felt so well—never felt so bad.

Cardiovascular variables, arterial blood pressures and heart rate were measured by a noninvasive oscillotonometric method (Dinamap). Before premedication, measurements were obtained after the patient had rested in the

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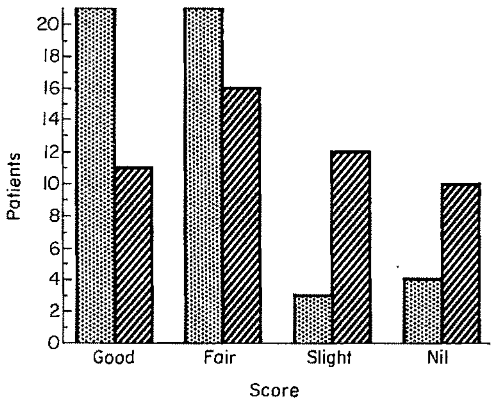

Fig. 1. The number of patients evaluated (by anaesthetists) with good, fair, slight or nil relief of anxiety respectively for each group. ▩, metoprolol; ▨, placebo.

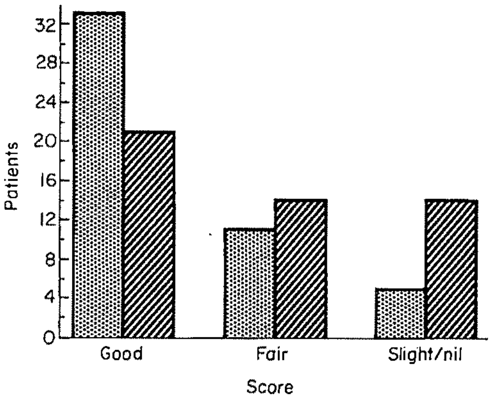

Fig. 2. The number of patients evaluated (by anaesthetists) with good, fair or slight sedation respectively for each group. ▩, metoprolol; ▨, placebo.

supine position for at least 15 minutes; the mean of three measurements were recorded. Before induction the mean of three measurements were again noted.

Nonparametric tests, Spearman rank correlation coefficient and Chi-squared test were used as appropriate for statistical analysis; $p < 0.05$ was considered significant.

Results

There were no significant differences between the groups in respect of age, sex, height and weight of the patients (Table 1).

Assessment by anaesthetist. The observations made by the anaesthetist are shown in Figures 1 and 2 and Table 2. Thirty-three patients receiving metoprolol and 21 who received placebo were scored as being well sedated, while five and 14 after metoprolol and placebo respectively were not, or only slightly, sedated ($p < 0.05$). Good relief of anxiety was achieved in 21 patients in the metoprolol group and 11 in the placebo group, while four and 10 patients were found to be without relief or even to be more anxious than before premedication ($p < 0.01$). Dizziness and nausea were present in one patient after metoprolol and two patients after placebo.

The average score, made by the anaesthetists, of sedation and anxiety are given in Table 2. In general, the patients who received metoprolol were found to have greater relief of anxiety ($p < 0.005$) and to be better sedated ($p < 0.001$).

Assessment by patients. The median values of the patient's own evaluation of anxiety, sedation, depression, relaxation and general status are given in Table 3. Patients in both groups found themselves significantly more sleepy and relaxed after premedication. No statistical difference was found between the groups. Patients in both groups after premedication found themselves calmer and less depressed than before premedication; this was significant in the metoprolol group ($p < 0.05$). Both groups were significantly more comfortable generally after premedication, but the patients who received metoprolol found themselves significantly more comfortable than those given the placebo ($p < 0.02$).

There was a significant correlation between the observer's scoring 'relief of anxiety' and patient's VAS delta values of anxiety ($r = 0.37$, $p = 0.003$, Spearman rank correlation).

The cardiovascular variables are shown in Table 4. No patient suffered any severe cardiovascular effects. Two patients in the metoprolol group had heart rates less than 50 beats/minute after premedication, and three between 50 and 55 beats/minute, compared to one and two patients respectively after placebo. In three patients who received metoprolol, mean arterial pressure decreased to less than 70 mmHg compared to two after placebo. The differences between the two groups were not statistically significant. A

Table 1. Demographic features of patients (mean, SEM).

	Metoprolol	Placebo
No. of patients	49	49
Age, years	37 (1.8)	40 (1.5)
Height, cm	171 (1.7)	168 (1.2)
Weight, kg	68 (1.7)	72 (1.7)
Male/female	19/30	21/28

Table 2. Sedation and relief of anxiety after assessment and questioning by the anaesthetist of the patient (mean, SEM).

	Sedation	Relief of anxiety
Metoprolol	1.6 (0.10)	2.2 (0.13)
Placebo	1.1 (0.12)	1.6 (0.15)
p	<0.001	<0.005

Table 3. Patient's self-relating (median and lower/upper quartiles)

	Metoprolol	Placebo	p
No. of patients	47	47	
Sleepiness			
before premedication	22 (7–47)	20 (8–47)	ns
before induction	67 (47–76)	58.5 (36–78)	ns
p	<0.001	<0.001	
Anxiety/apprehension			
before premedication	21 (10–43)	18 (7–46)	ns
before induction	12 (4–20)	11.5 (7–26)	ns
p	0.0044	ns	
Depression			
before premedication	18 (6–30)	17 (5–34)	ns
before induction	9 (4–18)	9.5 (4–22)	ns
p	0.045	ns	
Relaxation			
before premedication	28 (15–51)	41 (16–52)	ns
before induction	13 (6–23)	14 (9–30)	ns
p	<0.001	<0.001	
General status			
before premedication	39 (18–51)	46 (32–50)	ns
before induction	23 (11–40)	37 (24–45)	0.014
p	0.01	0.01	

Statistical evaluation: Mann–Whitney two-tailed test.
For further explanation see text.
ns, not significant.

Table 4. Cardiovascular variables before premedication and before induction of anaesthesia (mean, SEM).

	Metoprolol	Placebo	p
Systolic blood pressure			
before premedication	128 (2.2)	125 (1.6)	ns
before induction	120 (2.2)	127 (2.2)	<0.02
Mean blood pressure			
before premedication	94 (1.7)	93 (1.8)	ns
before induction	88 (1.8)	93 (1.9)	<0.02
Diastolic blood pressure			
before premedication	77 (1.4)	77 (1.6)	ns
before induction	73 (1.7)	76 (1.8)	ns
Heart rate			
before premedication	71 (1.5)	72 (1.7)	ns
before induction	64 (1.4)	76 (2.0)	<0.001

ns, not significant.

substantial number of patients in the placebo group showed an increase in heart rate[12] and mean arterial pressure,[8] compared to none in the metoprolol group.

Discussion

Few subjects in anaesthesia generate greater controversy than premedication. However there is little comparative data on the relative merits of drugs used for premedication; this is due in part to the different criteria by which the desired effects of these drugs are assessed and the difficulties in measuring sedation and apprehension.[1-9]

Several methods have been prescribed to assess sedation and anxiety, for example visual analogue scales completed by the patient[7-9] and assessments of the patient by the anaesthetist.[3,4,5,7,8] We used both methods, and while the observers found significant relief of anxiety, no difference was found in the patient's own assessment before induction of anaesthesia, although the patients in the metoprolol group found themselves significantly more calm after premedication, and significantly better when general status was assessed compared to placebo.

In accordance with a reduced level of anxiety, metoprolol reduces blood pressure and heart rate, but no serious side effects were observed. The reduction in heart rate and blood pressure was small, although one cannot exclude a potential risk of metoprolol treatment.

Both Male and Johnson[7] and Russell[8] found a relatively poor correlation between observers' rating and patients' VAS, which corresponds to the results in our study, where the correlation coefficient was small although significant. Two explanations are possible, if one presumes that the observers' results are correct. Firstly, patients found it difficult to judge their anxiety, and secondly, were reluctant to express their anxiety to an observer. Direct expression of feelings, in our normal interpersonal relationships, is only a small part of the assessment of how another is feeling. Facial expression, body position and movements all suggest an emotion, and these are usually accepted regardless of what is said. The visual analogue scale places emphasis on probably one of the least reliable expressions of anxiety. Taking this into account the observers' results are supported by the fact that differences were found in the patients' expression of their general status. Ratings obtained by a trained observer may be more sensitive than patients' rating on a visual analogue scale, as pointed out by others[7,8] To minimise the variation we suggest that all patients in such clinical trials be evaluated by the same person when using observers' ratings.

The effect of beta-adrenergic blocking drugs on tremor, stress and anxiety is not well defined, but the catecholamine levels probably are of some importance,[14,19,20] although a clear correlation is still to be demonstrated. Beta-blockade tends to increase catecholamine levels, but on the other hand blocks the effect of increased circulatory catecholamines. Therefore a possible explanation of the study results is that the beta-blocking drugs simply interrupt the vicious circle whereby anxiety produces somatic effects and the awareness of such effects results in increased anxiety.[18,19] This could be the reason for not only reduction in anxiety, as demonstrated by the observers, but also the demonstrated greater sedation in patients who received metoprolol. The results correlate well with earlier findings of the effect of beta-adrenoceptor blocking drugs in situations where anxiety or tension are well known, such as stage-fright in musicians,[10,11] examination nerves[12,13] and anxiety before public speaking.[20]

We found that metoprolol was well accepted and without serious side effects, so premedication with beta-adrenoceptor blocking drugs may be of value, although the potential side effect on cardiovascular function should be explored further.

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Anaesthesia, 1990, Volume 45, pages 43–45

Comparison of conventional and rapid inhalational induction of anaesthesia with enflurane

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Summary

Inhalational induction of anaesthesia using either a conventional method or a vital capacity breath of 4% enflurane in 67% nitrous oxide was compared in 30 adult surgical patients. Induction time was significantly faster in patients who took a vital capacity breath (71, SD 22 versus 132, SD 18 seconds, $p < 0.01$). There were no significant differences between groups in respect of systolic blood pressure, heart rate, arterial oxygen saturation or incidences of excitement or coughing. The vital capacity breath method was acceptable to 87% of patients.

Key words

Anaesthetic techniques; induction.
Anaesthetics, volatile; enflurane.

A technique of rapid inhalational induction of anaesthesia by means of a single vital capacity breath (VCB) has been described.[1] Studies of this technique have shown that induction time may be shortened considerably when compared with a conventional inhalational method.[2,3] The rapid induction technique was shown to be acceptable to patients and is associated with greater cardiovascular stability, fewer respiratory complications and less excitement. Halothane and isoflurane, either in oxygen or in nitrous oxide/oxygen, have been studied.[1-5]

The pungency and high MAC value of enflurane (in comparison with halothane) is said to limit tolerable inspired concentration,[5] retard induction by this method and be less acceptable to patients.[6] This study compares the use of enflurane for induction of anaesthesia by a conventional or VCB technique.

Method

Institutional ethics approval and patient consent were obtained for the study. Thirty adult patients (ASA 1 or 2) who presented for elective surgery received either a conventional (group 1) or VCB (group 2) induction technique. Groups were studied consecutively.

All patients were premedicated with atropine 0.01 mg/kg and secobarbitone 2 mg/kg intramuscularly 60–90 minutes before induction. Patients in group 1 received induction of anaesthesia with 67% nitrous oxide in oxygen and the inspired enflurane concentration was increased by 1% every 3 breaths up to a maximum of 4%. A single vital capacity breath of 4% enflurane in 67% nitrous oxide in oxygen was used in patients in group 2. Patients were instructed to breathe out maximally and then to inhale maximally from the anaesthetic system and to hold their breath for as long as comfortably possible before they resumed spontaneous breathing. In both groups inspired concentrations were maintained at 4% for a further 3 minutes after loss of consciousness. Anaesthetic gases were delivered at a fresh gas flow rate of 6 litres/minute by a Drager vaporizer into a Drager Narkomed 2A circle system with a 2-litre reservoir bag. The circle system was primed with the appropriate anaesthetic mixture using a calibrated Capnomac (Datex) before each induction.

Monitoring included a precordial stethoscope, continuous electrocardiography (ECG), automatic noninvasive blood pressure monitor, pulse oximetry and continuous measurement of inspired and end-tidal carbon dioxide (CO_2) and enflurane concentrations via the facemask angle piece.

Loss of consciousness was defined as the loss of response to eyelash touch and verbal command (eye-opening). Induction time was recorded as the interval between the start of the first conventional breath or vital capacity breath and loss of consciousness. Excitement was defined as any movement of the head or limbs during induction.

The length of the breath-holding and induction time were recorded. Heart rate, blood pressure and arterial oxygen saturation were recorded at one-minute intervals from the start of induction. The maximum end-tidal CO_2 concentration during induction and at the end of the breath-hold were recorded. The presence of excitement or arrhythmia at any time was noted. All recordings were

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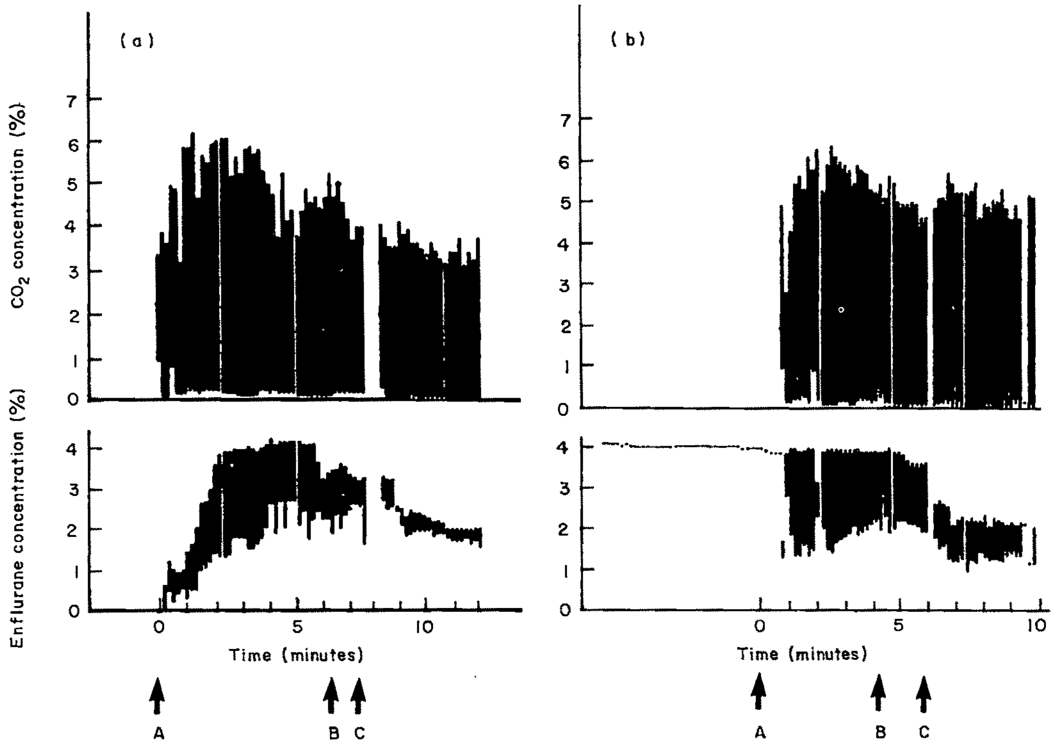

Fig. 1. Inspiratory and end-tidal CO$_2$ and enflurane concentrations during inhalational induction and for the succeeding 10 minutes. (a) conventional method, (b) VCB method. A; start of induction. B; administration of suxamethonium. C; tracheal intubation.

made by an independent observer. The patients' opinion of the technique was sought after recovery.

Statistical analysis of data was performed using an unpaired *t*-test or Chi-squared test with Yates' correction where appropriate.

Results

Details of the patients are shown in Table 1; the groups did not differ significantly. Induction time and breath-holding time (group 2 only) are shown in Table 2. Induction time for group 2 patients includes the period of breath-holding. Mean (SD) induction time was 132 (18) seconds in group 1 and 71 (22) seconds in group 2; this difference is significant ($p < 0.01$). Breath-holding time for the VCB manoeuvre in group 2 patients ranged from 18–102 seconds with a mean (SD) of 43 (24) seconds.

Figures 1(a) and (b) show typical tracings of end-tidal CO$_2$ and enflurane concentrations during induction and tracheal intubation.

Figure 2 shows the haemodynamic changes and arterial oxygen saturation associated with induction in both groups. There were no significant differences between groups in any of the variables at the times shown. At 5 minutes, systolic blood pressures in groups 1 and 2 were 87% and 85% of the respective control values. One patient in group 2 became hypoxaemic (Sao$_2$ 85%) during the second minute of induction. The lowest recorded saturation in group 1 was 93% (at 4 minutes).

Table 1. Patient details, mean (SD). Group 1; conventional inhalational induction. Group 2; vital capacity breath induction.

	Group 1 (n=15)	Group 2 (n=15)
Age (years)	43 (12)	39 (8)
Weight (kg)	54 (10)	57 (9)
Females	13	13
Males	2	2

The incidences of excitatory movements and coughing tended to be lower in group 2 (Table 3), but the differences were not statistically significant.

The mean (SD) maximum end-tidal CO$_2$ concentration at the end of the period of breath-holding (group 2 only) was 5.2 (0.8) kPa. The maximum end-tidal CO$_2$ recorded at any point during induction was 6 (0.6) kPa in group 1 and 5.8 (0.7) in group 2. The difference was not significant.

Table 4 shows the patient questionnaire and its results. One patient in group 1 was lost to follow-up. There were no statistical differences between groups. The smell of enflurane was considered unpleasant by 71% in group 1 and 73% in group 2. Nevertheless, 79% of patients in group 1 and 87% in group 2 stated that they would be happy to receive the same technique again.

Discussion

Concern with possible halothane-related liver damage[7] and the unavailability of isoflurane have determined the choice

Table 2. Breath-hold and induction times (seconds), mean (SD).

	Group 1	Group 2
Breath-hold	—	43 (24)
Induction time	132 (18)	71 (22)*

*$p < 0.01$.

Table 3. Incidences of excitement and coughing.

	Group 1	Group 2
Excitement	4 (27%)	2 (13%)
Coughing	2 (13%)	1 (7%)

Table 4. Results of questionnaire.

	Group 1 ($n=14$)		Group 2 ($n=15$)	
	Yes	No	Yes	No
Was the smell of gas pleasant?	4		4	
unpleasant?	10		11	
Did you remember the first breath?	10	4	11	4
Did you remember anything after this?	7	7	8	7
Would you have this technique again?	11	3	13	2

of volatile anaesthetic agent in this institution. The rate of increase of the enflurane vaporizer setting in the conventional inhalational induction, although arbitrary, followed our customary practice. Premedication was guided by the same considerations. A maximum of 4% enflurane was used in accordance with the distributor's recommendations (Dinabbott, Japan).

This study has shown that a VCB method of induction with 4% enflurane in nitrous oxide is rapid and associated with low incidences of excitation and coughing. The rationale behind the VCB method is that alveolar anaesthetic concentration, and consequently blood and brain concentrations, increase more rapidly and induction time is shortened.[6]

Pungency was a notable feature of enflurane in both groups, although apparently not unacceptable to the majority of patients. This is in keeping with a previous observation.[8] Pungency and a high MAC value were features of enflurane which were presumed to make VCB induction methods with this agent slow and unacceptable to patients.[6] Nevertheless, induction time was faster (71 seconds versus 83 seconds) and patient acceptability was similar (87% versus 91%) when compared with halothane.[2] Thus induction time is not retarded by pungency when enflurane is used in a VCB technique.

The patients in this study were premedicated and this may have contributed to the low incidence of airway irritation. Breath-holding times were comparable to those reported by other authors.[1-5] Clinically significant hypercapnia did not occur.

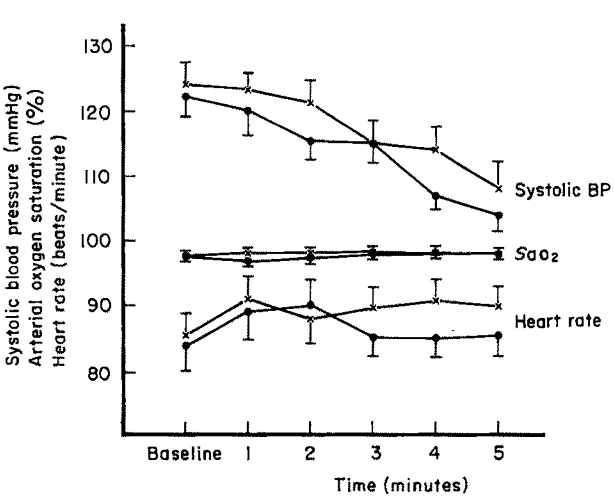

Fig. 2. Haemodynamic changes and arterial oxygen saturation during induction. Bars indicate SEM. x——x, group 1 (conventional); ●——●, group 2 (single breath).

Patient cooperation is essential in performing the single (or triple) VCB technique.[3,5] Conversely, excessive cooperation may also be detrimental; hypocapnia due to hyperventilation in practising the VCB delayed induction in one patient. This patient repeatedly practised the VCB manoeuvre before induction, remained apnoeic for 102 seconds and became hypoxaemic (Sa_{O_2} 85%) without losing consciousness; the mean end-tidal CO_2 concentration at the end of the period of apnoea was 3.8 kPa. Enflurane has potent depressant effects on the ventilatory responses to hypercapnia and hypoxaemia in awake patients,[9] and pre-induction hypocapnia may be expected to prolong induction until sufficient carbon dioxide is retained to stimulate ventilation.[10,11]

In summary, induction of anaesthesia by a single VCB method using 4% enflurane in nitrous oxide is rapid and acceptable to patients despite a pungent odour and a high MAC value. Haemodynamic changes and the incidences of excitement and coughing are similar to those during conventional inhalational induction with enflurane.

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Anaesthesia, 1990, Volume 45, pages 46–48

A jet nebuliser for delivery of topical anaesthesia to the respiratory tract

A comparison with cricothyroid puncture and direct spraying for fibreoptic bronchoscopy

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Summary

Topical anaesthesia of the respiratory tract for fibreoptic bronchoscopy was compared, in a single-blind study, inhaled from a simple and inexpensive jet nebuliser, administered by cricothyroid injection or by a 'spray-as-you-go technique'. Each technique was supplemented by spraying lignocaine through the fibrescope and intravenous fentanyl–droperidol sedation. Inhaled nebulisation was successfully used for 96% (46 of 48) of patients, was safe, effective and acceptable to the patient and bronchoscopist. The cricothyroid injection method produced better conditions than nebulisation in patients who had diagnostic bronchoscopy. The nebuliser technique is as satisfactory as the spraying technique in patients for diagnostic bronchial lavage in whom bleeding from a cricothyroid puncture is unacceptable. Patients who used the nebuliser were more satisfied. This technique may also be a useful method for 'awake' intubation.

Key words

Anaesthetic techniques; topical.
Equipment; nebuliser.

Bronchoscopy is often performed with local anaesthetic techniques which usually require considerable patient cooperation. Inhalation of nebulised lignocaine through a mouthpiece is a safe, effective and acceptable method of inducing topical anaesthesia for bronchoscopy.[1] However, ultrasonic devices are expensive and usually cumbersome. This study compares a simple and inexpensive nebuliser with the two topical anaesthetic techniques used routinely in the chest service for fibreoptic bronchoscopy. Each method is combined with oral and intravenous sedation.

Description of apparatus

The Aiolos apparatus (Fig. 1) is an inexpensive, portable, hand-held jet nebuliser developed in Sweden for economic humidification of inspired gas or administration of bronchodilator drugs to asthmatics, often in the patient's home. It is supplied with a gas regulator which fits on either a piped oxygen outlet or oxygen cylinder. It is made mainly of polypropylene, is easily dismantled for cleaning and can be sterilised either by autoclaving or soaking in chlorhexidine solution.

Method

The Ethics Committee approved the study and consent was obtained from each patient. Patients scheduled for fibreoptic bronchoscopy under sedation and topical anaesthesia were admitted under the care of two consultant chest physicians. Each patient was premedicated one hour before bronchoscopy with oral lorazepam 1 mg and intramuscular atropine 0.6 mg. An amethocaine lozenge (60 mg) was sucked by each patient as he (she) left the ward.

All patients in the study had the relevant topical anaesthesia technique applied by an anaesthetist (P.A.I or J.E.B) so that the study could be single-blind to the bronchoscopist.

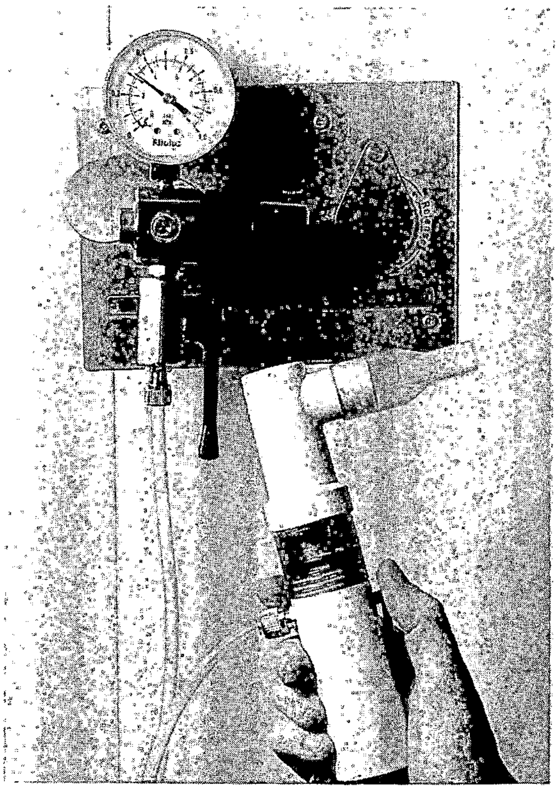

Fig. 1. The Aiolos jet nebuliser and gas regulator.

Patients were randomised to receive either their physician's usual topical anaesthetic technique, which was either cricothyroid puncture, topical anaesthetic delivered by a 'spray-as-you-go' (SAYG) technique, or lignocaine inhaled through the mouthpiece of the Aiolos apparatus.

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Table 1. Physical characteristics of patients and percentage who were smokers. Values expressed as mean (SD).

Groups	*n*	Weight, kg	Age, years	Smokers, %
Consultant A				
Cricothyroid puncture 1	26	66.4 (13.7)	58.7 (13.1)	69
Nebuliser 2	22	65.7 (14.2)	59.7 (14.5)	65
Consultant B				
Nebuliser 2	26	73.2 (13.5)	53.4 (15.4)	50
Spray-as-you-go 3	24	71.8 (15.6)	59.3 (12.2)	41

Each patient had continuous ECG monitoring, and arterial blood pressure was measured before and after bronchoscopy. An 18-gauge intravenous cannula was inserted and a mixture of fentanyl and droperidol (Thalamonal—fentanyl 50 μg, and droperidol 2.5 mg, per ml) was administered over one minute. Each patient was given 1.5 ml Thalamonal per 50 kg/body weight. Topical anaesthesia was then applied.

Group A1 (Consultant A—using cricothyroid puncture)

A cricothyroid puncture was performed and 4 ml lignocaine 4% injected (160 mg).

Group A2 (Consultant A—using the nebuliser)

Patients were instructed to inhale through the mouthpiece and exhale through the nose. A total of 4 ml lignocaine 4% (160 mg) was administered by continuous nebulisation which took 8–10 minutes to complete. All consultant A's patients had an adhesive dressing applied over the cricothyroid membrane to blind the operator to the technique used.

Group B2 (Consultant B—using the nebuliser)

These patients had topical anaesthesia applied in the same fashion as for consultant A (Group A2).

Group B3 (Consultant B—using 'spray-as-you-go')

Ten squirts of lignocaine 10% (100 mg) were sprayed over the back of the tongue from a metered dose aerosol (Astra Pharmaceuticals). After this, 4 ml lignocaine 4% (160 mg) were sprayed through the fibreoptic bronchoscope directly onto the vocal cords. The total dose of lignocaine used was therefore 260 mg.

In all groups, 2-ml aliquots of lignocaine 2% (80 mg) could be given directly through the bronchoscope onto the bronchial mucosa as thought necessary by the bronchoscopist. Additional boluses of 1 ml Thalamonal were given if sedation was judged inadequate. Immediately after bronchoscopy three 100-mm long visual analogue scales were completed by the physician to assess conditions above the vocal cords, from the cords to the carina, and the overall conditions for bronchoscopy during the procedure (0 = impossible conditions, 100 = very good conditions).

All patients were visited within 2–4 hours of operation and two visual analogue scales were completed to assess the patients' opinion of the pleasantness/unpleasantness of the topical method and the comfort/discomfort of the overall procedure (0 to 100 mm for each assessment). The main comparisons were between groups constituted by random allocation: A1 compared with A2 and B2 compared with B3. Standard statistical tests were used, including the *t*-test and Mann–Whitney test, wherever the assumption of Gaussian distributions was inappropriate.

Results

Ninety-eight patients were studied. The demographic data is shown (Table 1). Consultant B's patients were, on average, heavier and fewer smoked. Bronchoscopy was completed in every patient except two in group A2 who had nebulised lignocaine. These patients were subsequently given a transtracheal injection of lignocaine (160 mg) and bronchoscopy was successfully performed. The analyses reported here adhere to the 'intention to treat' principle.[2] These two nebuliser failures were assigned the poorest scores for quality of outcome in order to count them as preferences against the nebuliser. Alternative analyses conditional on the ability to use the allocated technique, in which these two subjects were excluded, gave very similar results.

The initial doses of Thalamonal were the same, although patients treated by consultant A received significantly more additional intravenous sedation ($p < 0.01$) than those of consultant B (Table 2). However, there were no significant differences between groups treated by each consultant. Eighty-three percent of patients required additional doses of lignocaine which in two patients exceeded 500 mg (Table 3). There were no important differences between operators or groups.

Table 2. Numbers of patients given extra fentanyl and droperidol.

	Extra fentanyl and droperidol, ml				
Group	1	2	3	4	
Consultant A					
Cricothyroid puncture 1	3	1	0	1	N.S.
Nebuliser 2	3	4	1	1	
Consultant B					
Nebuliser 2	2	0	0	0	N.S.
Spray-as-you-go 3	1	0	0	0	

Groups A1 and A2 received more intravenous drug than Groups B2 and B3 ($p<0.01$).
NS, Not significant.

Table 3. Numbers of patients given extra 2% lignocaine in ml.

	Extra 2% lignocaine, ml									
Group	0	2	4	5	6	7	8	10	12	14
Consultant A										
Cricothyroid puncture 1	9	5	3	0	3	0	4	2	0	0
Nebuliser 2	3	5	7	0	4	0	2	3	1	1
Consultant B										
Nebuliser 2	3	4	2	8	0	1	4	1	0	1
Spray-as-you-go 3	2	2	7	1	8	0	1	1	0	0

No significant differences between the groups.

Table 4. VAS for quality of topical anaesthesia. Values expressed as mean (SD).

	Bronchoscopy conditions		
Group	Above the cords	Below the cords	Overall
Consultant A			
Cricothyroid puncture 1	83 (22)	85 (22)	75 (21)
	*	†	†
Nebuliser 2	57 (34)	44 (21)	43 (24)
Consultant B			
Nebuliser 2	81 (29)	68 (32)	75 (26)
	N.S.	N.S.	N.S.
Spray-as-you-go 3	71 (31)	69 (32)	66 (28)

*Significant $p<0.002$.
†Significant $p<0.001$.
NS, Not significant.

The visual analogue scores which assessed the physician's view of the quality of topical anaesthesia (Table 4) in consultant A's group were better for conditions above the cords ($p < 0.002$), below the cords and overall for the A1 compared with the A2 group ($p < 0.001$). In consultant B's group, the visual analogue scores were not significantly better above the cords and overall for the nebulised group (B2) compared with B3. There was a difference in visual analogue scores at all levels between the nebulised groups. The patients' scores for the overall comfort of the procedures showed no differences between the A1 or A2 groups (Table 5), but patients treated in group B3 recorded higher scores (i.e. more unpleasant) than those in B2 ($p < 0.05$). The scores of the patients' opinion of the unpleasantness of the procedures showed that mean group A1 scores were 19.3 (SD 19.7) and mean B3 scores were 25.4 (SD 22.6). These were not significantly different. All patients who received nebulised lignocaine found the technique very acceptable.

Discussion

Local anaesthesia for bronchoscopy must produce adequate anaesthesia, be safe for the patient and easy to apply for the patient and physician.[3] Nebulisation is believed to produce a more thorough and even application of the agents to the entire mucosa of the respiratory tract.[4] Nebulised lignocaine in this study, produced satisfactory anaesthesia in 96% (46 of 48) of patients. In addition, it did not prevent the remaining two patients from additional local anaesthesia by a different technique. No toxic effects of lignocaine were observed either peri-operatively or thereafter, although in some patients the total dose of lignocaine exceeded the recommended dose. None of the patients found use of the nebuliser unpleasant, but three patients, one with multiple sclerosis and two with severe rheumatoid arthritis, found the operating handle very difficult to depress. Other patients complained of similar difficulty and it was sometimes necessary to offer assistance.

Patients' visual analogue scale for overall comfort of the procedure showed no important differences between groups A1 and A2, although group B2 patients found the procedure more comfortable than group B3. Moreover, consultant A's patients received significantly more intravenous sedation than consultant B's. This almost certainly reflects differences in technique between operators.

Cricothyroid injection of local anaesthetic agents is not recommended if diagnostic bronchial lavage is planned since it can contaminate the respiratory tract with blood. Therefore, nebulisation may be a preferred method of topical anaesthesia for diagnostic bronchial lavage. Fibreoptic intubation of an awake patient is a technique used increasingly by anaesthetists for an anticipated difficult intubation. We have used the Aiolos nebuliser to provide an inexpensive and effective method of topical anaesthesia for this procedure in a small number of patients. This will be the subject of a separate report.

Table 5. Patients VAS for overall comfort of procedure. Values expressed as mean (SD).

Group	VAS
Consultant A	
Cricothyroid puncture 1	51 (28)
	N.S.
Nebuliser 2	53 (28)
Consultant B	
Nebuliser 2	27 (21)
	S
Spray-as-you-go 3	42 (23)

S, Significant $p<0.05$.
NS, Not significant.

Acknowledgments

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Goldenhar's syndrome: an analysis of anaesthetic management
A retrospective study of seventeen cases

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Summary

Seventeen patients with Goldenhar's syndrome who had surgery 28 times are presented. Various authors have reported problems in the anaesthetic management of these patients, but we encountered significant difficulties in only one. Three anaesthetic techniques were used. A thorough pre-operative assessment with back-up facilities for difficult intubation are important. Additional cardiorespiratory and craniovertebral anomalies may necessitate modifications in the basic techniques.

Key words

Intubatian, tracheal; difficult.

Goldenhar[1] first described a syndrome that consisted of pre-auricular appendages, fistulae and epibulbar dermoids. Hollowich and Verbeck[2] later described another patient who conformed to this syndrome and reviewed 33 other cases reported since the original article. Other manifestations have been added since Goldenhar's original description; they include vertebral anomalies, upper lid colobomata, subconjunctival lipomata, ear abnormalities, hearing loss, unilateral facial hypoplasia, micrognathia, cleft or high-arched palate, mental retardation, renal abnormalities and congenital heart disease.

The terms oculovertebral dysplasias and oculo-auriculovertebral dysplasias are used to describe this syndrome. Feingold and Baum[3] listed criteria, of which at least two were required for a diagnosis of Goldenhar's syndrome. These included eye abnormalities such as lipoma, lipodermoid, epibulbar dermoid, in association with any of the following: ear, mandible or vertebral anomalies.

Material and methods

Seventeen cases, seven males and 10 females aged from 22 days to 12 years and diagnosed as Goldenhar's syndrome according to the criteria laid down by Feingold and Baum were anaesthetised a total of 28 times for ocular surgery over a period of 10 years. The patient profile, the abnormalities and their incidence encountered in this retrospective study are listed in Tables 1 and 2. Three anaesthetic techniques were used in the management of the patients (Table 3). They were either intubated with suxamethonium after induction with oxygen, nitrous oxide and halothane and maintained with halothane or trichloroethylene; or intubated with suxamethonium after induction with thiopentone/oxygen, nitrous oxide and halothane and maintained with either tubocurarine, gallamine, or pancuronium, and a narcotic technique with intermittent positive pressure ventilation; or induced and maintained with oxygen, nitrous oxide and halothane using a nasopharyngeal airway.

Surgical techniques ranged from lamellar keratoplasty, tarsorrhaphy, needling and syringing, and dermoid excision, dicated with intramuscular atropine 0.01 mg/kg one hour before induction. Patients were induced with oxygen, nitrous oxide and halothane in 10 out of 28 anaesthetics, and after assessment of the ability to ventilate their lungs artificially, their tracheas were intubated after a normal dose of suxamethonium. Anaesthesia was then maintained with oxygen, nitrous oxide and halothane, while the patient breathed spontaneously. Intravenous increments of pethidine were used (0.5–1 mg/kg) for analgesia.

Anaesthesia was induced, in five of 28 patients, with thiopentone and they were intubated using a normal dose of suxamethonium after the possibility of assisted ventilation was confirmed. Balanced anaesthesia was maintained with a narcotic–relaxant technique. All patients were extubated after reversal of the non-depolarising block, with neostigmine and atropine.

The other 13 anaesthetics were in patients who were to have short procedures, such as examination under anaesthesia and stitch removal and were induced with oxygen, nitrous oxide and halothane, after an intravenous line and monitoring were set up. Anaesthesia was maintained with a lubricated nasopharyngeal airway inserted in the more patent nostril (tested previously) which was then connected to a Jackson–Rees modification of Ayre's T-piece. The mouth and the other nostril were sealed with nonallergenic adhesive tape to ensure an air-tight system. This further enabled us to assess the patient's breathing by observation of the respiratory bag's movements. The nasopharyngeal airway was inserted until the bag's movements were free and maximal. The nasopharyngeal airway was fixed to the face at this position with nonallergenic adhesive tape.

Monitoring included observation of colour, chest and respiratory movements, pulse, electrocardiograph, temperature and blood pressure. A total of 13 surgical procedures were conducted with this technique without any complications. Pulse oximetry was a valuable adjunct to the other monitors in the last few cases. The airway was removed, suction performed and the patients were allowed to awaken under monitoring at the end of the procedure.

The above approach was satisfactory in these patients. The only difficulty was in a one-year-old female for eyelid repair who had marked micrognathia which had hampered insertion of a small Macintosh laryngoscope blade. No

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Table 1. Goldenhar's syndrome: summary of patient abnormalities.

Age (years)	Sex	Oral abnormality	High-arched palate	Cleft lip/ palate	Mandibular hypoplasia	Micro-gnathia	Bony abnormality	Spina-bifida	Scoliosis	Ear defects	Hearing loss	Abnormal shape/size	Pre-auricular tags	Abnormal position	Mental retardation
1	F	+				+				+		+	+	+	
3/12	M	+		+						+			+		
12	F	+	+				+		+	+	+	+	+		+
4	F									+			+	+	
3	M	+			+					+			+		
6	M									+	+		+	+	
11	M						+		+	+	+		+		
5	F									+			+		
1	M	+		+			+	+		+				+	
10	M						+		+	+	+	+			+
2	F	+				+	+	+		+			+		
22/7	F	+		+						+		+	+		
13	F						+	+		+	+	+			
4	F	+			+					+			+		
2/12	F	+		+						+		+	+		
1	F	+				+				+			+		
6	M						+	+		+		+	+	+	
Total	17	10	1	4	2	3	7	4	3	17	5	7	14	5	2

Table 2. Goldenhar's syndrome, ocular manifestations.

Age (years)	Sex	Coloboma eyelid	Sub conjunctival lipoma	Extra-ocular muscle defect	Epibulbar dermoid
1	F	+			
3/12	M	+			+
12	F	+	+		+
4	F	+	+		+
3	M				+
6	M	+	+		
11	M		+		+
5	F	+	+		
1	M		+		
10	M				
2	F		+		
22/7	F				+
13	F			+	+
4	F	+			
2/12	F	+			
1	F	+			
6	M	+		+	
Total	17	10	7	2	7

other paediatric laryngoscope was available and it was decided to maintain anaesthesia with a nasopharyngeal airway. This was uneventful with a normal recovery.

Discussion

Goldenhar's syndrome is considered to be a variant of the first and second branchial arch syndromes, with an uncertain incidence and variable genetic penetrance. No familial tendency is reported. There are no universally accepted features for recognition and definition of the syndrome in spite of the original description by Goldenhar[1] and the criteria laid down by Feingold and Baum[3] Patients with the rare syndrome present a challenge to the anaesthesiologist. Craniovertebral anomalies, accompanied by moderate to severe congenital cardiac defects and associated secondary respiratory problems, together with mental retardation in a single patient calls for expertise of the highest order. Previous reports[4] document patients with Goldenhar's syndrome who had surgery deferred because they could not be intubated.

We encountered no such difficulties in our series. The sole patient with mandibular hypoplasia could be intubated without marked difficulty. The only problem was encountered in a case of micrognathia and this patient was managed with a nasopharyngeal airway.

Airway problems may occur in patients with Goldenhar's syndrome. The uneventful conduct of anaesthesia and surgery in the present series may be attributed to a number of reasons. All the patients were thoroughly screened during the pre-anaesthesia visit; the anaesthetic approaches were discussed and the possibility of a tracheostomy explained to the patient. In addition, head and neck movements and mouth opening were assessed before operation and all patients had X rays of the cervical spine and the face (skull and jaw). The Schwartz hyoid manoeuvre was useful[4] in assessing further the difficulty anticipated during intubation. This measures the anterioposterior distance from the middle of the inside of the mentum of the mandible to the hyoid bone and gives an approximate idea of the potential space for laryngoscopy. The distance is measured by gently placing fingers between the mentum and the hyoid bone. The minimum distance for a normal airway in adults is about 3 cm (two fingers). The distance in infants and children is proportionately smaller, about 1.4–1.5 cm in the new born. A decrease in this potential space serves as a signal for the anaesthesiologist to be prepared for difficult intubation.

All cases were elective with backup facilities for difficult intubation, and the consultant anaesthesiologist available in the operation theatre. The co-existent presence of all anomalies is a factor that compounds the problem of difficult intubation. Fortunately this was not seen in our series of 17 patients.

Only one of our patients (a 22-day-old female) had a ventricular septal defect in addition to an epibulbar dermoid. She had two anaesthetics; the first was for an eye examination and the second for removal of the dermoid. On both occasions, the child was induced with oxygen, nitrous oxide and halothane, intubated after suxamethonium and maintained on controlled ventilation with a Jackson–Rees modification of Ayre's T-piece. Pancuronium and morphine were used to maintain relaxation and provide analgesia. Surgery and recovery were uneventful.

Earlier studies have reported an incidence of 35%[5] for congenital heart disease in Goldenhar's syndrome and of 40%[5] for vertebral deformities. It is difficult to explain the low incidence of congenital heart disease in our series.

Anaesthetic techniques for patients with Goldenhar's syndrome depend on the type, extent and severity of craniofacial/vertebral anomaly, the associated cardiovascular problems, which include cardiorespiratory reserve, the level of mental abnormality/retardation, and the nature of surgery, whether major or minor, emergency or elective.

Premedication should be judiciously titrated or omitted depending on the patient and surgery proposed. Anticholinergics alone or combined with other premedicant drugs (anxiolytics and sedatives in small doses) may be used. A nasopharyngeal technique avoids intubation in short procedures, but maintains an adequate airway in a day care patient who may otherwise pose intubation problems. It also facilitates surgery, and allows more space for the surgeon. We maintained satisfactory anaesthesia in 10 patients with this technique.

We have found that gaseous induction in various other abnormalities is unsatisfactory. Intravenous induction agents, such as thiopentone (4–6 mg/kg) or ketamine (1–2

Table 3. Goldenhar's syndrome, anaesthetic management.

Number of patients	Induction	Maintenance	Respiration	Airway
10	Oxygen, nitrous oxide, halothane	Suxamethonium, oxygen, nitrous oxide, halothane, trichloroethylene	Spontaneous	Tracheal tube
5	Thiopentone	Suxamethonium, tubocurarine, gallamine, pancuronium	Controlled	Tracheal tube
13	Oxygen, nitrous oxide, halothane	Oxygen, nitrous oxide, halothane, trichloroethylene	Spontaneous	Nasopharyngeal airway

mg/kg or 5–7 mg/kg intramuscularly) are preferable. Ketamine offers an advantage of producing dissociative anaesthesia, for short procedures, but it did not find favour with the authors. It is known to increase intra-ocular pressure, cause nystagmus, stimulate excessive saliva and may not offer airway protection. Movement makes its use unsuitable for microsurgery.

Airway patency is of prime importance. Patients should be intubated whenever possible but not if there is a risk of causing laryngeal trauma by repeated attempts. Various aids to oro- or nasotracheal intubation, including retrograde intubation,[6] may be tried and, when essential, elective tracheostomy may be performed. All patients should be extubated when protective airway reflexes are present, and if necessary the tube should be left in place until the patient is fully recovered.

Anaesthetic management of patients with Goldenhar's syndrome calls for a thorough examination, an anaesthetic technique tailored to the clinical situation and adequate monitoring. Airway protection is a prime objective but not at the cost of laryngeal trauma. A nasopharyngeal airway may be helpful.

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Local application of EMLA and glyceryl trinitrate ointment before venepuncture

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Summary

One hundred unpremedicated fit day surgery patients aged between 27 and 68 years were allocated randomly into one of four groups and EMLA, glyceryl trinitrate, EMLA and glyceryl trinitrate or a placebo ointment was applied to the dorsum of a hand. The pain and ease of venepuncture were determined at induction of anaesthesia 60 minutes later. Pain scores were also reassessed 1–2 hours after operation. Lower pain scores and easier venepuncture occurred when EMLA and glyceryl trinitrate ointment was applied to the dorsum of the hand.

Key words

Anaesthetics, local; eutectic mixture of local anaesthetics.
Pharmacology; glyceryl trinitrate.

EMLA (Eutectic Mixture of Local Anaesthetics) contains lignocaine, prilocaine, emulsifier, an agent to increase viscosity, and water. Many studies have shown its efficacy in provision of local anaesthesia of intact skin in infants, children and adults.[1-6] Glyceryl trinitrate 2% ointment (Percutol) causes local vasodilatation which facilitates venepuncture.[7]

Method

One hundred fit adult male or female patients admitted to a day care unit to undergo surgical procedures were studied. They were not premedicated. The study was double blind and randomised. Patients were all visited by the anaesthetists before surgery when the design of the study and the rating scale were explained.

The patients were allocated randomly into one of four groups. Patients in group 1 received EMLA and glyceryl trinitrate (GTN), group 2 a placebo (KY jelly), group 3 EMLA only and group 4 GTN only. In group 1, one inch of GTN ointment (approximately 1–2 mg) was applied to the dorsum of one hand and rubbed well into the skin. EMLA 2.5 g (half the contents of the tube) was then applied to the area of the skin treated with GTN ointment and an occlusive plastic dressing was placed over the area. Patients in groups 2, 3 and 4 received placebo, EMLA and GTN respectively, and a dressing was applied as in group 1. The ointments were left in contact with skin for 60 minutes and then wiped off by a nurse before the patient went to the operating theatre, and the application site was marked.

A 23-gauge butterfly needle was inserted percutaneously

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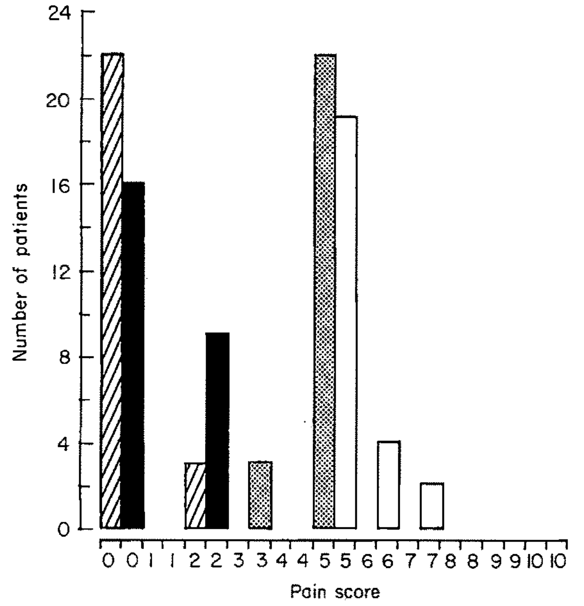

Fig. 1. Pain scores at venepuncture. ▨, EMLA; ■, EMLA+GTN; ▩, GTN; □, KY jelly.

before induction of anaesthesia. A tourniquet was applied above the wrist. The skin was not cleaned with antiseptic before venepuncture. The patient's evaluation of pain by a verbal rating scale of 1 to 10 was recorded. The anaesthetist evaluated the venepuncture subjectively as very easy, usual, difficult or very difficult. Any reaction of the skin to the ointment was also recorded. All the patients were visited after operation; reactions to ointment or discomfort were noted and the pain rating was re-assessed.

Data were analysed using the Kruskal–Wallis test for nonparametric data.

Results

The ages of the patients ranged from 27 to 68 years. Figure 1 shows pain scores recorded at the time of venepuncture. Figure 2 shows the anaesthetists' assessment of ease of venepuncture.

There were highly significant differences between the groups for both pain scores ($p < 0.001$) and ease of venepuncture ($p < 0.001$). Further analysis of the pain scores demonstrated that the differences between EMLA alone and EMLA and GTN were not statistically significant from each other, but the data for these two groups were statistically different from the other two ($p < 0.001$). Similar analysis of the data related to ease of venepuncture indicated that there was no significant difference between the EMLA and GTN group and GTN alone, but the data from these two groups were statistically different from the other two ($p < 0.001$).

There were no significant differences among groups in respect of pain scores after operation.

Two patients in group 1 and nine patients in group 2 showed pallor of skin on the application site after the ointment had been wiped off. The blanching of the skin lasted 1–2 hours after operation. No pallor of skin was seen in other patients. No erythema or allergic response to any of the ointments occurred. Three patients who received EMLA only and two who received EMLA and GTN described numbness of the hand which lasted for up to 2 hours after operation. Blunt sensation of a needle was experienced by some patients during venepuncture.

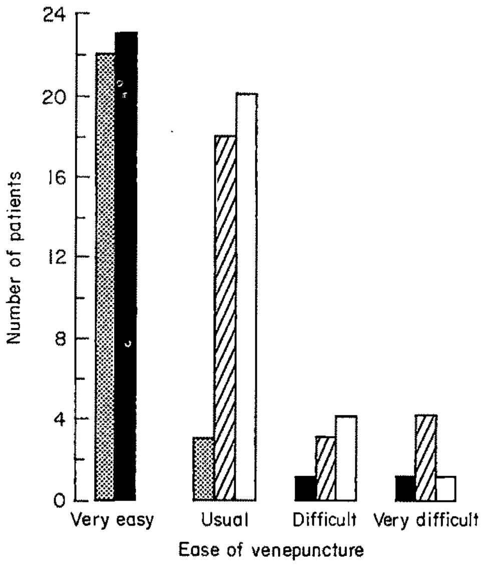

Fig. 2. Anaesthetist's assessment of ease of venepuncture. ▨, EMLA; ■, EMLA+GTN; ▩, GTN; □, KY jelly.

Discussion

Local anaesthetic creams used for mucosal surfaces are ineffective on intact skin because of poor penetration of the drug. EMLA penetrates all layers of skin,[4] although most of the active constituents remain in the superficial stratum corneum. Toxic concentrations of drug have not been reported in plasma after many hours of EMLA application,[3] although methaemoglobinaemia was reported.[8] Juhlin *et al.*[9] found that the effect of EMLA cream persisted for up to 2 hours after application.

One study[10] showed that the use of ethyl chloride spray to freeze skin before venepuncture was less effective than EMLA in children. Another study,[11] in which laser-induced pain was used and cortical responses measured, indicated that pain sensation was blocked after application of EMLA for 80 minutes and all sensation after application for 100 minutes in adults. Pain block was also achieved 30 minutes after a 30-minute application of the cream.

Vasoconstriction of the skin has been suggested as the cause of pallor after EMLA application, but only two out of 25 patients in the EMLA and GTN group showed pallor of the hand in this study. It has been suggested[12] that blanching seen with EMLA could be caused by moisture under the occlusive dressing. This study was carried out during winter in unpremedicated day care patients who arrived about 1–2 hours before surgery. Anxiety and the cold weather could have contributed to vasoconstriction. Patients who received GTN and EMLA cream or GTN ointment only at the time of induction had warm hands with prominent veins on the treated side.

No obvious general systemic effect was observed from the small amount of GTN applied. The amount was one-seventh of that recommended as a trial dose in patients with angina.[13]

Acknowledgment

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Pulse oximetry in methaemoglobinaemia

The paper by Rieder *et al* (*Anaesthesia* 1989; **44:** 326–7) is an interesting case report, but the authors are not clear in what they mean with the notation 'saturation', presumably due to the confusion between saturation (So_2) and oxyhaemoglobin fraction ($FHbO_2$).

Oxygen saturation (So_2) refers by definition[1] to that part of the haemoglobin concentration in the blood that can combine reversibly with oxygen. Normally, through various causes, blood contains small amounts of haemoglobins that are, temporarily or permanently, unable to bind oxygen (dyshaemoglobins).[2] The most common dyshaemoglobins are methaemoglobin and carboxyhaemoglobin. Consequently,

$$So_2 = \frac{{}^{c}HbO_2}{{}^{c}HbO_2 + {}^{c}Hb} = \frac{{}^{c}HbO_2}{{}^{c}Hb(tot) - {}^{c}Hb(dys)}$$

$$\approx \frac{{}^{c}HbO_2}{{}^{c}Hb(tot) - ({}^{c}MetHb + {}^{c}HbCO)} \qquad \text{equation 1}$$

where ${}^{c}HbO_2$, ${}^{c}Hb$, ${}^{c}Hb(tot)$, ${}^{c}MetHb$ and ${}^{c}HbCO$ are the concentrations of oxyhaemoglobin, de-oxyhaemoglobin (sometimes referred to as reduced haemoglobin), total haemoglobin, methaemoglobin, and carboxyhaemoglobin, respectively.

Oxyhaemoglobin fraction ($FHbO_2$) is defined as

$$FHbO_2 = \frac{{}^{c}HbO_2}{{}^{c}Hb(tot)}$$

$$\approx \frac{{}^{c}HbO_2}{{}^{c}HbO_2 + {}^{c}Hb + {}^{c}MetHb + {}^{c}HbCO} \qquad \text{equation 2}$$

$FHbO_2$ is often (mis) interpreted as saturation. In normal blood, which contains only small amounts of dyshaemoglobins, these two quantities are nearly equal, but, in the presence of increasing amounts of dyshaemoglobins, $FHbO_2$ decreases while So_2 remains the same. With the large amount of MetHb ($FMetHb$, 64%) as found in the case reported, it is confusing to report $FHbO_2$ and refer to it as saturation.

The finding that a pulse oximeter does give erroneous results with high concentrations of either MetHb and (or) methylene blue is not surprising since such a two-wavelength measuring system is disturbed by a substance in the blood that also absorbs light in one of the spectral regions of the measuring system. This drawback of pulse oximetry is well known.[3-5] A spectrophotometric multicomponent analysis is only possible using a multiwavelength analysis.

The use of controlled ventilation in this patient with 100% O_2, resulted in an arterial Po_2 53.5 kPa, $So_2 = 100\%$ *by definition* (equation 1). However the interference both by MetHb and methylene blue resulted in pulse oximeter readings of 85% and 72% respectively. These are not *over* estimated but *under* estimated saturation readings.

This misinterpretation may lead to unwanted and unnecessary therapeutic interventions such as IPPV with 100% O_2. Only in the case of CO poisoning one can assume that an Fio_2 1.0 results in a faster cure of the patient due to the competition of O_2 and CO at the binding site in the haemoglobin molecule.

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A reply

Thank you for the opportunity to reply.

Professor Oeseburg correctly reminds us about the nomenclature and definition of 'saturation'. Unfortunately there are a lot of synonyms for this term: So_2 or saturation is identical to functional (oxygen) saturation (So_2(funct)) and defined[1] as 'blood oxygen saturation percentage determined as 100 times oxygen haemoglobin divided by oxygen binding capacity (of haemoglobin)': $So_2(\%) = 100(HbO_2)/(Hb + HbO_2))$, where HbO_2 is the concentration of oxyhaemoglobin and Hb the de-oxyhaemoglobin concentration. Oxyhaemoglobin fraction ($FHbO_2$), also called oxygen saturation,[2] fractional oxygen saturation (So_2(frac)) or oxyhaemoglobin percentage, contributes to the confusing variety of names.[1] Pulse oximetry values have been defined as pulse oximetry saturation in initial reports originating from the manufacturers of pulse oximeters[1] and this term is now commonly used in clinical practice and abbreviated as Spo_2 in the literature as, for instance, in a similar case report of methaemoglobinaemia.[3] There is continuing discussion about the correct meaning of pulse oximeter values and different opinions and classifications were recently presented in the literature. Severinghaus[1] states that pulse oximetry does not distinguish between HbO_2 and HbCO because it uses only two wavelengths and probably also includes Hbmet in the measurement of HbO_2: $Spo_2(\%) \simeq 100\ (HbO_2 + HbCO + Hbmet)/(Hb + HbO_2 + HbCO + Hbmet)$, where HbCO is the concentration of carboxyhaemoglobin and Hbmet is methemoglobin concentration.

This equation can be modified as follows: $Spo_2(\%) \simeq 100\ (Hbtot - Hb)/(Hbtot)$ where Hbtot is the concentration of total haemoglobin and includes Hb, HbO_2, HbCO and Hbmet.[1]

We may therefore, according to Severinghaus, regard the pulse oximeter as a desaturation meter, where DSat(%) is $100\text{-}Spo_2$.[1] The simple assumption is that pulse oximetry as a desaturation meter or functional or fractional saturation meter is not accepted by Barker,[4] who could show an overestimation of So_2 by pulse oximetry in the presence of methemoglobinaemia. We agree that pulse oximeter saturation of 85% and 73% respectively in our case report with a patient with 64% methemoglobinaemia underestimated 'real' saturation in the sense of arterial or functional saturation, but overestimated fractional saturation or oxyhaemoglobin fraction according to the definition of Professors Zijlstra and Oeseburg.[5] Despite the presence of a high functional saturation and arterial partial pressure in this case report we believe that use of 100% oxygen was mandatory and lifesaving in the presence of hypoxaemic neurological and metabolic dysfunction with only minimal arterial oxygen content.

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Carboxyhaemoglobin

Much of the knowledge about levels of carboxyhaemoglobin (COHb) in the general population result from surveys of blood donors.[1,2] It is also known that any COHb in donated blood remains virtually intact throughout normal blood bank storage life.[2,3] The routine use of a cooximeter on our intensive therapy unit has detected increased COHb after blood transfusion in a number of our critically ill patients. We would like to report two of these cases.

A 73-year-old man, who normally smoked up to 10 cigarettes per day, was admitted with a bleeding duodenal ulcer. An arterial blood sample taken during resuscitation indicated a total haemoglobin level of 8.1 g/dlitre, with a COHb level of 1.2%. The ulcer was oversewn at laparotomy and the patient received six units of blood during and immediately after operation. The COHb level of 4.8% was then measured. The COHb levels in samples from the six near empty units in the order infused were 0%, 2.2%, 0%, 0%, 6.7% and 5.2%. Despite oxygen therapy, 36 hours passed before the COHb levels before transfusion were attained.

A 65-year-old man was admitted for closure of colostomy. This unfortunately broke down, and the patient developed septicaemia and multiple fistulae into his wound. A formal repair was attempted after a month of ventilation of his lungs and parenteral nutrition. The patient bled profusely during the operation and for the first 6 hours afterwards. Thirty units of blood were given during this time, and the patient's COHb level rose from undetectable to 3.8%. COHb was detected in five out of 30 of the units at levels of 6.9%, 5.5%, 3.9%, 3.1% and 2.8%. It took 10 days before the patient's COHb level decreased below 1%, because of his continued need for blood, some of which also contained COHb.

The levels of COHb in these patients thus increased by over 3% as a result of their blood transfusions. The clinical significance of COHb introduced in this manner, at these levels, into the critically ill is unknown, but is not likely to be favourable. There are some implications. Pulse oximetry cannot be relied upon to detect COHb increases.[4,5] Work in dogs has suggested that these instruments treat COHb as if it were 90% oxyhaemoglobin.[4] This is because they assume that oxyhaemoglobin is most of the portion of the total haemoglobin that is not reduced haemoglobin.[5] Shunt calculations are rendered false unless COHb levels are taken into account. Closed breathing systems should not be used in patients with COHb because any carbon monoxide excreted is rebreathed.

Anaesthetists should be aware that increased COHb may result from blood transfusion, and that the consequent reduction in oxygen carriage may be of importance in some groups of patients.

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Inheritance of low plasma cholinesterase

The article by Drs Whittaker and Berry and Miss Britten (*Anaesthesia* 1989; **44:** 480–2) was interesting. However, I must take issue with their claim to have recognised the $E_1^kE_1^s$ genotype. They have done nothing of the sort. Their paper contains no conclusive evidence for the Kalow cholinesterase variant in any patient. Its presence is inferred from guesswork and a series of highly questionable assumptions.

They have supposed that when the E_1^k allele occurs in conjunction with E_1^s the enzyme activity will be 33% less than that found in $E_1^uE_1^s$ heterozygotes, the same difference as that seen between $E_1^uE_1^k$ and $E_1^uE_1^u$ individuals. There is no evidence of which I am aware for such a proposition.

They postulate that patients within a family who have the same cholinesterase activity have the same genotype. Such a contention is quite fallacious.

However, the matter that is of greatest concern is the basis which the authors have used for their reference range for cholinesterase activity. This information is fundamental to their article and yet no indication is given of the source of the figures quoted. For their argument to have any substance whatsoever the reference range must be derived from activities measured on healthy members of a population *representative of* and *exclusively from* those on whom convincing evidence can be supplied that they are E_1^u homozygotes.

Such people are rare e.g. phenotypically usual children of two $E_1^uE_1^a$ parents. If the authors have managed to assemble material from such a group they will have achieved what no other cholinesterase laboratory of which I am aware has done, including my own. It is much more likely that the figures they report were derived from people labelled $E_1^uE_1^u$ for lack of evidence to the contrary. That being so, it will be falsely low if $E_1^uE_1^k$ or $E_1^uE_1^s$ patients have been included, or falsely high if a cut-off point has been drawn which excludes other genotypes but also those who are genuinely $E_1^uE_1^u$ but who lie in the lower part of the activity spectrum.

Until the details of the reference population are known it is not possible to assess the reliability of the cholinesterase activity range quoted and hence any possible validity for their proposition. Despite these serious reservations it would still have been perfectly proper for them to have presented their findings as a hypothesis, however tenuous. Regrettably, they have not restricted themselves to this but allowed flimsy evidence to obscure their ability to differentiate between conjecture and fact.

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A reply

Many of Dr Evans' doubts about our recent paper on the inheritance of low plasma cholinesterase activity could be resolved by better acquaintanceship with the literature. Many workers have indicated that alleles appear to determine structurally distinct forms of an enzyme. These structural differences are also associated with quantitative differences in the total amount of enzyme activity produced.[1] This applies to cholinesterase. Thus the E_1^K allele will be associated with 66% of the usual E_1^U allele[2] independent of its combination with the E_1^U, E_1^S or the E_1^F allele.

We appreciate Dr Evans' difficulty in accepting that 'individuals within a family who have the same cholinesterase activity have the same genotype' but we have substantiated our hypothesis by genetic analyses as well as by evidence obtained from individuals known to have the genotype $E_1^KE_1^S$ and these data are quoted in our paper.

Our reference range for the usual genotype is based on the fact that during the past two decades we have investigated 2345 families, 95% of whom have been referred as suxamethonium-sensitive. Approximately 40% of the propositi of these families are homozygote E_1^A, E_1^A. Both parents must in other words have an E_1^A gene.

We are sure that Dr Evans will appreciate that a high proportion of these parents are heterozygote $E_1^UE_1^A$ since only about 13% of the heterozygotes with an E_1^A allele are $E_1^AE_1^K$, fewer are $E_1^AE_1^F$, whilst $E_1^AE_1^H$ and $E_1^AE_1^J$ are very rare. The homozygote $E_1^AE_1^A$ is also rare. It must be accepted from basic genetic principles that 25% of the siblings of $E_1^AE_1^A$ individuals from $E_1^UE_1^A \times E_1^UE_1^A$ matings will be $E_1^UE_1^U$.

It is fair that Dr Evans should caution any assignment of rare genotypes to unusual family data, but we would like to stress that we have re-investigated family 1 after a period of 19 years. We feel that, until the $E_1^UE_1^K$, $E_1^KE_1^K$ and $E_1^KE_1^S$ genotypes can be recognised by biochemical analyses, our present interpretation of our data is justified.

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'Intra-operative hearing' under general anaesthesia

Several reports exist about patients' awareness of some sensations and their awakening during surgery, as well as on intra-operative hearing under general anaesthesia. Unconscious perception or wakefulness without recall may occur during chemical anaesthesia and is documented by case studies. The verbal recollection of repressed memory during anaesthesia was possible after operation in some cases, using special hypnotic techniques. It is also asserted that complications can result from careless conversations or alarming remarks made at critical times during chemical anaesthesia. On the other hand, patients may benefit from positive suggestions given under general anaesthesia. Well controlled studies[1] have reported on the nonverbal response to intra-operative conversation and documented the beneficial effect of positive suggestions given under general anaesthesia.

However, more recently Boeke *et al.*,[2] with their methodologically modified study failed to replicate their previous findings.[1,3] Originally, they found statistically significant differences in the duration of hospital stay after operation between patients who had positive suggestions during general anaesthesia and groups exposed to noise or operating room sounds.[3] They reported similar advantages with the use of positive suggestions for older patients.[1] On the other hand in their more recent report,[2] they administered seaside sounds to all patients in all groups, before and after the presentation of the experimental sounds, and did not find a statistically significant difference.

It is known that environmental sounds evoke right hemisphere dominance and so do the majority of musical and hypnotic tasks.[4,5] Moreover music, together with environmental sounds (like the seaside sounds) facilitate relaxation, the induction of hyponosis, and have been found to be advantageous for surgical patients.[6] These sounds have been proven to produce an anxiolytic effect.

These findings should be considered before any conclusions are drawn from Boeke and co-workers'[2] replicative study, in which seaside sounds, as filter sounds, were administered for *all* groups in addition to the experimental sounds.

There are some contradictions in the literature about the value of intra-operative suggestion, which should be kept in mind, but a recent double-bind randomised placebo-controlled study also reported on improved recovery and reduced postoperative stays after therapeutic suggestions during general anaesthesia.[7]

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Declaration of Helsinki

The title page of *Anaesthesia* states that investigations performed on man should conform to appropriate ethical standards. One source of such standards is the Declaration of Helsinki. In medical research combined with professional care (clinical research) the declaration states: 'In any medical study, every patient—including those of a control group, if any—should be assured of the best proven diagnostic and therapeutic method'.

A paper recently published in *Anaesthesia* by Hardy (*Anaesthesia* 1989; **44:** 398–9) described the treatment of patients with chronic pain using stellate ganglion block. The dose of agent used was deliberately reduced until no sympathetic block was detected. I do not consider that this clinical research provided the patient with the best therapy: in fact the study design depended on detecting ineffective therapy. One of the basic principles of the declaration of Helsinki is that 'Concern for the interests of the subject must always prevail over the interests of science and society'. Since the procedure used in the study is not without risk, yet the treatment provided was ineffective, I feel that concern for the patient's interests has not prevailed.

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Fear and anaesthesia

All aspects of our practice, including the use of the anaesthetic room, should, I agree with Drs Soni and Thomas (*Anaesthesia,* 1989; **44:** 651–5), be kept under continuous reappraisal. However, my conclusions from their findings would be rather different from theirs.

Patients on psychotropic, antihypertensive drugs or betablockers were excluded, as were those for cancer-related operations. Thus not only the patients who would have experienced the most anxiety at induction of anaesthesia but also those in whom that anxiety would have had the most seriously adverse effects were not studied.

Secondly, although I am sure that their patients, who gave informed consent, were adequately prepared psychologically for induction, nevertheless they had modest doses of temazepam. The current data sheets for four brands of temazepam[1] give the dose recommended for premedication as 20–40 mg. This young group of patients could have benefited from an increased dose. This view is supported by the fact that all the variables measured, in both groups of patients, showed an increase of anxiety at the time of induction, despite a brief waiting time. Perhaps the correct conclusion is that under-premedicated patients are as anxious when induced in the anaesthetic room as when induced in the operating room.

The paper repeats two serious misconceptions about monitoring in the anaesthetic room. Monitoring, either clinical or electronic, during induction in the anaesthetic room, is entirely feasible provided only that anaesthetists are prepared to resist the tendency to overload our already over-heavy anaesthetic machines with monitoring equipment. This equipment can be much more conveniently put on a separate trolley which can then be used in the anaesthetic room (or even in entirely different parts of the hospital). Monitoring can then be continued during transfer of the patient into the operating room, and the benefits of the anaesthetic room, for those of us who believe in them, can still be safely enjoyed without unnecessary duplication of equipment. The paper also repeats without comment the argument that the use of the anaesthetic room can reduce the delay between cases. My personal experience is that I regularly have to wait until the operating room is ready for me to transfer my patient onto the operating table, even after a visit to the recovery room with the previous patient.

Dr Soni invokes experience in Holland to reinforce the belief that anaesthetic rooms are unnecessary. My experience in Sweden, where patients were induced in anaesthetic rooms, was that fear was a predominant emotion at induction. Its manifestations were, for cultural reasons, rigorously repressed, often to the cardiovascular detriment of the patients. We should be cautious of extrapolation of the methods in other countries to our own patients. Safety must clearly be paramount, but it is not necessarily best served by induction of anaesthesia in the operating room. Before we, it seems inevitably, abandon our anaesthetic rooms, let us not forget that fear in surgical patients is a very real problem and also has its bearing upon safety; not only may the adrenergic response to fear produce potentially dangerous cardiovascular responses but fear induced by dogmatic insistence on particular procedures may affect the patient's future attitudes towards hospitals in general.

Two recent patients of mine (one who died) have refused hospital treatment because of fear. Two other patients needed treatment with major tranquilisers before they would consent to admission for surgery. Would any of these patients (three of whom would have been excluded from Soni and Thomas' trial) be better served by the insistence on induction of anaesthesia in the operating room?

Our obstetric colleagues are already finding that some expectant mothers choose to deliver at home rather than submit to impersonal and frightening treatment in some hospitals; please may we not be tempted to make our treatment of patients so frightening that they likewise refuse to attend for surgical procedures.

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1. ASSOCIATION OF THE BRITISH PHARMACEUTICAL INDUSTRY. Data Sheet Compendium, 1989–90, pp. 189, 477, 1780, 1793.

A reply

We are grateful for the opportunity to reply to the points raised in Dr Young's letter.

It is necessary in comparative trials to exclude all variables other than those to be measured. We therefore excluded patients on psychotropic drugs and those scheduled for cancer-related operations. We also excluded those on cardioactive drugs because of their effect on the objective indices of anxiety. This is in line with the precedent set by other authors who have studied anxiety.[1,2]

The dose of premedication was carefully chosen. If our premedication were as heavy as Dr Young suggests we would not be able to perform the linear analogue test, and they would have shown no anxiety at either site of induction. There seems to be a widespread tendency to use less premedication, especially for day case surgery which makes up 28% of our case load.

We agree with the suggestion that all the monitoring apparatus should be on a separate trolley which moves with the patient from the anaesthetic room to theatre. However, this still involves disconnexion from the electric supply during the transfer to the table and the management of trailing wires and tubes presents problems. Induction in theatre gives complete continuity of monitoring. It is interesting that Dr Young believes that the use of anaesthetic rooms does not speed up the change-over between cases.

We should not blindly extrapolate the methods of our colleagues overseas to our own practice, but we consider that in many countries which use no anaesthetic rooms the patients do not differ markedly from our own in temperament. Perhaps patients would be less anxious if they understood that they were continuously monitored from start to finish; those patients mentioned by Dr Young whose anxiety gives rise to potentially dangerous cardiovascular responses are most in need of continuous monitoring.

We have all encountered the grossly nervous patients who break down completely on admission to hospital or fail to call their doctor for fear of an operation; these are few in number and will always require special treatment such as several days on tranquillisers and manifest their severe anxiety irrespective of the site of induction.

We are surprised that such a staunch defender of anaesthetic rooms as Dr Young should regard their abandonment as 'inevitable'. Does he really mean this, or did he intend to say that once they are lost we may not regain our anaesthetic rooms?

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Possible malignant hyperpyrexia

We wish to report an episode of malignant hyperpyrexia (MH) in a child who may have had several minor awake episodes prior to the development of the full syndrome in response to anaesthesia.

The patient was a 12-year-old boy who was admitted for tonsillectomy. He had had three short 'fits' in the preceding 6 months which were under investigation, but which required no treatment.

Atropine was given as premedication and anaesthesia was induced with thiopentone and suxamethonium. He developed masseter spasm; however tracheal intubation and inflation of the chest was possible. The rigidity was noted to be general. His lungs were ventilated with nitrous oxide, oxygen and isoflurane for a few minutes with no improvement, so anaesthesia was terminated. His core temperature measured at this time was 39.4°C and he was immediately transferred to intensive care.

Blood was dispatched for arterial blood gas analysis, urea and electrolytes, and baseline creatinine kinase. He was found to be hyperkalaemic (8.0 mmol/litre) and acidotic (base deficit 6.9 mmol/litre) and initial urine was strongly positive for myoglobin.

His lungs were hyperventilated using midazolam and vecuronium infusions for sedation, and cooling packs applied to axillae and groins. Dantrolene was given initially as a bolus and continued as an infusion. The temperature started to decrease soon after, so he was allowed to awaken and his trachea was extubated 4 hours after admission.

Initial creatinine kinase was 1784 IU. This increased to a peak of 68 275 IU 22 hours after the event. Renal function remained unimpaired, and he had no recrudescence of temperature. He was discharged back to the ENT ward after 48 hours in intensive care, and was allowed home 2 days after that.

There was no family history of anaesthetic problems. The patient's mother described his fits as episodes during which he became rigid with tightly clenched cheeks, cyanosed, and very hot. There were no convulsive movements. This lasted a few minutes and was very striking on one occasion; the other episodes were similar but less marked. There appeared to be no precipitating factors. An EEG was normal but a paediatrician considered that these episodes were likely to be benign childhood epilepsy. This family were referred to the malignant hyperpyrexia investigation unit in Leeds, where muscle biopsy subsequently showed that the patient was MH susceptible.

There have been a number of reports of putative 'awake episodes' of malignant hyperpyrexia in humans.[1,2] From the striking description our patient's mother gives of his fits they clearly share some of the features of classical malignant hyperpyrexia. It is of course easy to invest these episodes with a greater significance retrospectively, but it

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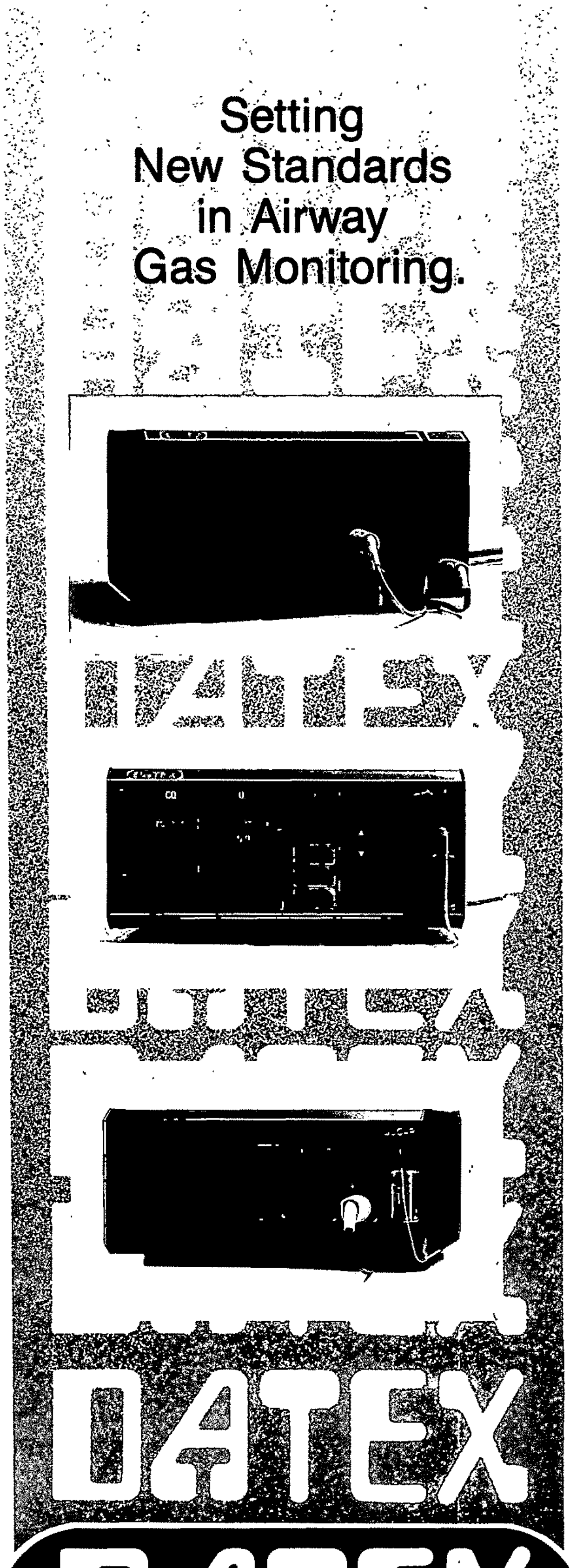

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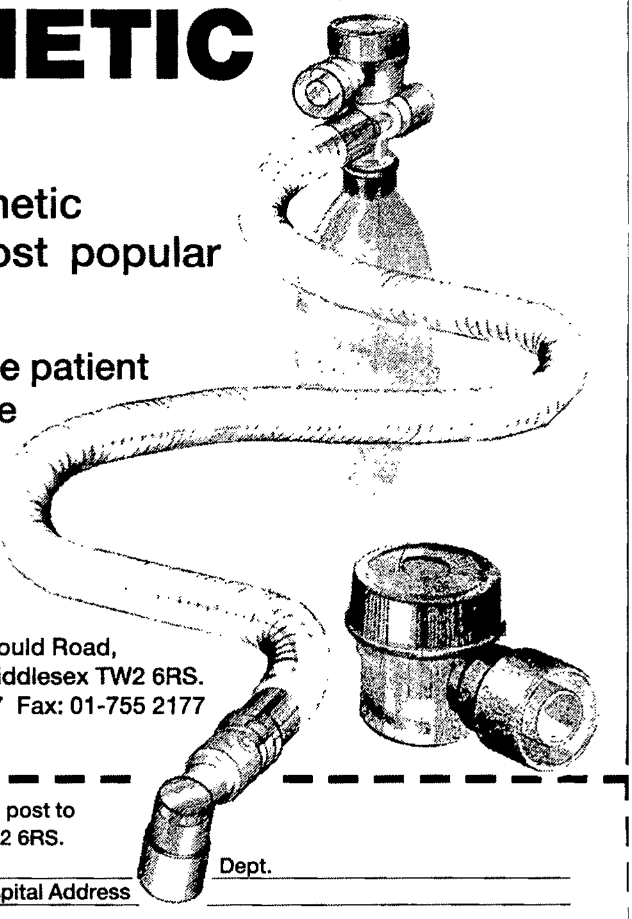

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may be possible that minor episodes such as these occur commonly in MHS patients.

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Collapse of the lung during hemithyroidectomy

A 56-year-old woman who had recently returned from Nepal presented for a hemithyroidectomy after a small mass was detected at a routine medical examination. Her general health was good and the only significant feature in her past medical history was a transient episode of aplastic anaemia 25 years previously. She had not smoked for 6 months.

The patient was asymptomatic and euthyroid before operation. A recent ear infection had been treated with antibiotics. No abnormality was found on clinical examination. All investigations before operation (apart from mean corpuscular volume, 103 femto litres), were within normal limits. A chest X ray was not taken.

The patient's trachea was intubated with an armoured Portex tracheal tube. Air entry was confirmed in both lungs by auscultation. Monitoring included an ECG, noninvasive blood pressure measurement, oximetry and airway pressure. Air entry to both lungs was reconfirmed after the patient was placed on the operating table. Surgery started 20 minutes after the induction of anaesthesia. The airway pressure increased from 2.5 to 3.0 kPa after 15 minutes. Examination of the chest demonstrated preferential ventilation of the right lung. Auscultation confirmed diminished air entry to the left lung. The $S\text{ao}_2$ remained stable at 98% and the blood pressure and pulse rate unchanged.

A pneumothorax was unlikely since the operation was at a preliminary stage, the saturation and cardiovascular variables were stable and the chest not hyperresonant to percussion. The tracheal tube position was confirmed by direct laryngoscopy and its patency confirmed by repeated passage of a suction catheter. The neck was partly dissected and all the monitored variables were stable so it was decided that the operation should continue.

A chest X ray on completion of the surgery demonstrated extensive collapse of the left lung. Rigid bronchoscopy was then performed and a large mucous plug removed from the left main bronchus. No other abnormality was found. The collapsed lung was readily re-expanded and confirmed by a further X ray. The patient was extubated without difficulty. *Haemophilus influenzae* was subsequently isolated from the mucous plug. The patient's postoperative course was uneventful.

Mucous retention is a not uncommon cause of pulmonary collapse in debilitated patients. However, it is an unusual event during an operation in an apparently well and asymptomatic patient. The patient admitted later to having had a recent upper respiratory tract infection but did not volunteer the information beforehand because it had apparently resolved.

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Topical lignocaine; ? toxic lignocaine

Lubricating gel containing local anaesthetic is widely available and is used for a variety of procedures. We report a case of hypotension after its use and point out some of its potential hazards.

A fit 37-year-old male who weighed 100 kg presented for laminectomy and discectomy. He was premedicated with temazepam 20 mg and metaclopramide 10 mg orally, one hour prior to induction. His arterial blood pressure was 130/90 mmHg and pulse rate 80/minute on arrival in the anaesthetic room. ECG monitoring was started, intravenous access established and 0.1 mg fentanyl given. When the patient noticed the effects of the fentanyl, thiopentone 450 mg induced anaesthesia and suxamethonium 100 mg was then given. The trachea was intubated and the patient's lungs ventilated via a Bain system with oxygen 3 litres/minute and nitrous oxide 5 litres/minute, with 0.5% isoflurane as supplement. Vecuronium 8 mg was used for neuromuscular blockade. Blood pressure was recorded using the Datascope 3000 (Datascope Corp) and was 100/80 mmHg, pulse rate 76/minute. The patient was catheterised using 'Instillagel' (Clini Med) lubricant gel. The gel contained 200 mg lignocaine and the patient was closely monitored.

The lungs were then ventilated using a Manley ventilator and at a minute volume of 8 litres with a V_T 700 ml. A period of hypotension occurred that started 5 minutes after catheterisation and lasted 15 minutes. The blood pressure dropped to 75/150 mmHg, pulse rate 70/minute, but this responded to an infusion of 1000 ml crystalloid and 500 ml colloid solution and withdrawal of isoflurane. There was no bradycardia or rhythm disturbance and the other variables monitored did not alter ($F\text{io}_2$, inflation pressure, oxygen saturation, end-tidal carbon dioxide, posture of patient).

We decided to continue when the systolic blood pressure had returned to 90 mmHg. The patient was turned into a prone position on the laminectomy cushion and the table broken by 15° with the lower legs angled upwards. The surgeon then performed a caudal epidural (20 ml bupivacaine 0.25%) and later infiltrated the wound site with 10 ml 1% lignocaine and adrenaline 1:200 000. Surgery proceeded uneventfully and postoperative recovery was normal. The patient's cardiovascular system was stable. This patient received 200 mg lignocaine in the lubricant jelly, 50 mg bupivacaine epidurally and a further 100 mg of infiltrated lignocaine in the course of 25 minutes.

The hypotension was unusual although not severe in the light of the modest doses of anaesthetic agents used. One possible explanation for the hypotension is the negative inotropic effect of absorbed lignocaine. The 'Instillagel' data sheet states that the gel adheres well to mucosa and is useful in all types of catheterisation, endoscopy, or intubation; most worryingly, it is recommended for colorectal use in paediatrics.

The data sheet recommends an initial 11 ml application

(200 mg lignocaine) followed by an additional instillation of 6–11 ml as required (100–200 mg) (total 200–400 mg lignocaine). It states that complete anaesthesia of the urethra, including the external sphincter, occurs in 3 to 5 minutes, and suggests that absorption occurs through the transitional and stratified squamous epithelium of the urogenital tract. The data sheet does mention that hypotension, bradycardia and muscle cramp may occur as an effect of systemic lignocaine when the urethra is damaged, although no cases are reported.[1]

Even if only a proportion of the lignocaine used is absorbed, the amount present in a single application of the gel exceeds the standard toxic dose for individuals who weigh less than 60 kg, if 3 mg/kg is the toxic dose.[2] This is especially relevant in paediatric practice considering the variable absorption of drugs via the rectal route.

This case brought our attention to the risks inherent in the random usage of anaesthetic lubricant gel and the relatively large amount of lignocaine present. It would be prudent to use the gel as sparingly as possible. In the situation above, plain lubricating jelly should have been used as the patient was already anaesthetised. Our main concern is the risks if this preparation is used without discrimination in paediatrics.

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Recurrent anaphylactoid reaction during Caesarean section

The case report from Dr Jackson and colleagues (*Anaesthesia* 1989; **44:** 585–7) was interesting since the events described bear many similarities to a case encountered by myself.

A healthy 21-year-old gravida 2+0 female with a history of asthma since childhood, hayfever and penicillin allergy, was admitted for elective Caesarean section under extradural anaesthesia. She had undergone an uneventful emergency Caesarean section in her previous pregnancy. Her only medication was salbutamol by inhaler. Premedication was with oral ranitidine; extradural anaesthesia to T_3 level ($L_{3/4}$ catheter) was instituted with 0.5% bupivacaine 23 ml in divided doses. Arterial blood pressure was 140/90 mmHg before extradural blockade and 130/85 mmHg at commencement of surgery. A thousand millilitres of Ringer Lactate solution and ephedrine 10 mg were administered during the establishment of the block, and up until delivery the patient lay supine with 15° left lateral lilt. Ten units of synthetic oxytocin (Syntocinon) were administered by bolus injection on delivery of the infant. Shortly thereafter, the patient became nauseous, and after a further 5 minutes the systolic blood pressure decreased to 65 mmHg. Blood loss was unremarkable. The level of sensory block was unchanged. The patient started to sneeze uncontrollably, moderate facial oedema was noted, and bronchospasm could be heard on chest auscultation. There was no rash. Rapid fluid infusion was commenced, ephedrine 15 mg intravenously and salbutamol administered by inhaler, and the patient breathed 100% oxygen through a facemask. Improvement gradually occurred without recourse to further measures over the ensuing 25 minutes and surgery continued without further event.

An anaphylactoid reaction to syntocinon was suspected and intradermal tests according to Fisher[1] performed using 1:10 and 1:100 dilution syntocinon, and normal saline. All tests were negative in control subjects. Testing in the patient was negative at 48 hours, but unequivocally positive for 1:10 dilution at 5 days and at 1 year after the reaction. Probable sensitivity to synthetic oxytocin was concluded.

Possible anaphylactoid reactions to synthetic oxytocin have been previously reported in the literature.[2,3] It is surprising that Dr Jackson and colleagues make no mention of the administration of an oxytocic agent at any time in the obstetric history of the patient they describe. Could this factor have been overlooked?

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A reply

Thank you for the opportunity to reply to this letter.

The discussion in our article about this point was eliminated during editing. We decided to avoid the use of oxytocin in view of the close relationship between delivery of the infant and the patient's previous reaction. This decision was made despite the negative result yielded by skin testing performed some weeks after her previous reaction.

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Resuscitation procedures

The Special Article Anaesthesia and the Law (*Anaesthesia* 1989; **44:** 606–7) makes very pertinent emphasis of the need for patient monitoring, skilled assistance for the anaesthetist, and proper resuscitation facilities and equipment to be available at all times when anaesthesia is administered. However, some of the points reported in connexion with the Sheriff's criticism of the anaesthetist in the case report disturb us.

Respected authorities, such as the American Heart Association, the Resuscitation Council (UK), and the Australian Resuscitation Council, having studied the appropriate literature, all recommend defibrillation in

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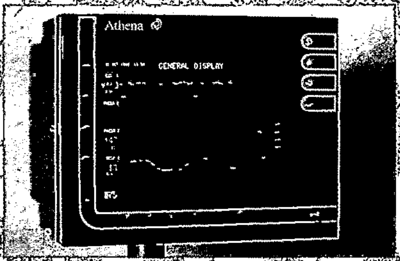

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patients with ventricular fibrillation as soon as possible after cardiac arrest has occurred, provided that the patient is reasonably well oxygenated. It is stated quite categorically in the report of this case that artificial ventilation was being provided by the dentist using a Brook airway and the anaesthetist believed that there was sufficient oxygenation of the patient to permit defibrillation. Given these conditions, defibrillation must take precedence over an attempt at tracheal intubation.

One might question with the benefit of hindsight certain details of the resuscitation attempt. But, assuming that ventricular fibrillation was present, the anaesthetist seems to have the priorities between defibrillation and tracheal intubation right. We are concerned that this report may cause doctors to delay defibrillation in favour of other resuscitative procedures, such as tracheal intubation and intravenous cannulation which could have an adverse effect on outcome.

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The Graseby adult apnoea alarm

The recent guidelines on minimal monitoring issued by the Association of Anaesthetists of Great Britain and Ireland,[1] have focused attention on the need for monitoring equipment throughout the peri-operative period. There are as yet no inexpensive, reliable devices available for monitoring ventilatory function, particularly in the postoperative period. Adult apnoea alarms currently in use have proved disappointing, and the significant delay in desaturation, secondary to apnoea, makes the oximeter a poor apnoea alarm.

We are evaluating a new battery-powered adult apnoea alarm (Graseby). A plastic casing measuring 16 × 8 × 2.5 cm encloses the alarm system, and it is connected to the patient by standard nasal cannulae. Small changes of pressure in the nasal cannulae caused by expiration are detected and displayed both as an audible click, and as a flashing red light. The alarm sounds if no pressure changes are detected for either 10 or 20 seconds depending on the initial programming. The device is very robust and sustained no damage when dropped from 4 feet and compressed by the weight of standard nurses or hospital beds.

We used the prototype alarm in the recovery unit on 50 patients after various operative procedures and all the medical and nursing staff concerned thought that the alarm was useful for postoperative monitoring. It is easy to use, requires no special training, and, far from being obtrusive, the clicking is helpful in recording the ventilatory rate. Patients tolerate the cannulae well, and even the excessive movement encountered in a few patients in the immediate recovery period did not trigger the alarm. All patients received oxygen while the alarm was being tested.

The alarm worked extremely well in 41 patients. Problems occurred in those patients who were breathing through an oral airway, or when a nasogastric tube occluded one nostril. The nasal cannulae did not detect the ventilatory pressure changes under these circumstances, but adaptation of the system by connecting the alarm cannulae to the mask through which oxygen was delivered, overcame some of these difficulties. However in six patients, two with a nasogastric tube and four who were edentulous, a seal around the mask proved difficult to maintain.

The alarm is sensitive to very small pressure changes, so alteration of the oxygen flow rate via the facemask will infrequently cause pressure fluctuations in the system sufficient to prevent the alarm sounding in the presence of apnoea. This was the case in three patients, and in five patients the alarm did not sense some of the shallow breaths, and gave rise to false alarms. Altering the sensitivity of the alarm decreased this small incidence of false alarms and improved the accuracy of the device. One patient would not tolerate either the nasal cannulae or a facemask, and thus probably did not require this method of monitoring. The alarm proved very reliable and helpful in the recovery period when these difficulties had been overcome, although a visual display of the ventilatory rate and an external sensitivity control would be desirable in the modification of this device.

Further evaluation of the alarm is necessary, but initial trials indicate that the Graseby adult apnoea alarm will be a useful addition to the monitoring equipment currently available.

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Reference

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Respiratory arrest after caudal bupivacaine

We wish to comment on the case report by Lumb and Carli (*Anaesthesia* 1989; **44:** 324–5) in which they describe a respiratory arrest after a caudal injection of bupivacaine in a 3.5-year-old boy.

We consider that a lack of appreciation of the physiological differences between adults and children allowed them to arrive at an incorrect diagnosis. Accidental subarachnoid injection is dismissed as a possibility because no cerebrospinal fluid was aspirated, the sequence of events was too sudden and there were no cardiovascular disturbances. Instead, they suggest that the caudal injection raised intracranial pressure (ICP) to such an extent that prolonged apnoea resulted. We believe the sequence of events in this case most likely resulted from an accidental subarachnoid injection (probably partial), and that ICP was not a contributing factor.

The cases in the literature about loss of consciousness after caudal anaesthesia[1,2] (quoted by Lumb and Carli) all relate to adults and appear to have a number of features in common. Either known pre-existing raised ICP was present,[1] or the injectate consisted of a large volume (between 40–60 ml) given rapidly through a 19-g needle.[2] Caudal blocks were administered to two patients in the latter situation with chronic lower back pain; the large volume rapid injection was deemed necessary to divide suspected adhesions. Both these patients lost consciousness for 20–30 seconds accompanied by muscle twitching and did not require resuscitation. Pressure changes within the epidural space during injections of local anaesthetics are governed by the rate of injection, the compliance of the epidural space and the rate of leakage through the intervertebral or sacral foramina.[3] Presumably the caudal injection given by Lumb and Carli was not given with undue speed, and in any event they used a 23-g needle which would have limited the injection rate. Coupled with this, the compliance of the epidural space in children is much greater than in adults,[4] which would also tend to limit pressure changes. It would therefore appear most implausible that ICP was raised to such an extent in this case, so as to produce apnoea which lasted an hour.

Dural puncture followed by accidental injection into the subarachnoid space (SAS) is an ever present complication of caudal anaesthesia. Needle aspiration alone may not detect a dural tap since the negative pressure may cause part of the cauda equina to block the end of the needle.[5] There is an invariable tendency to advance the needle[5] unless the needle hub is held firmly in relation to the skin. Children under the age of 6 show little or no change in heart rate or blood pressure after spinal or extradural analgesia.[4,6] This remarkable cardiovascular stability has been attributed to a less well developed sympathetic nervous system than in the adult, or a lower extremity blood volume that is a smaller fraction of the total blood volume than that in the adult. Bailey *et al.*[7] reported a case of a high spinal in a 5-kg infant after intrathecal hyperbaric tetracaine. Respiratory difficulty that required tracheal intubation developed within minutes and despite the absence of volume loading, there were no haemodynamic changes. Thus one cannot rule out an accidental subarachnoid injection due to the absence of cardiovascular disturbances, or indeed the absence of CSF on needle aspiration.

We believe that the sequence of events in the case presented by Lumb and Carli most likely resulted from an accidental injection of bupivacaine in the subarachnoid space, perhaps by misplacement of the needle during the course of the injection. It is our practice when performing caudals in children to insert the needle without an attached syringe. We aspirate before the local anaesthetic is injected, as well as (at least once) during the course of the injection, at which point we also disconnect the syringe and observe for CSF or blood. Should placement of the needle be in doubt at any time, a small amount of air is injected rapidly while auscultating over the lumbar area,[8] although this test is rarely required in children.

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Doxapram for respiratory depression after epidural morphine

Epidural morphine is commonly used in the treatment of pain after major surgery. Respiratory depression is an undesirable complication associated with its use. Intravenous naloxone is recommended both as prophylaxis and treatment. A variety of side effects are reported after intravenous naloxone; loss of analgesia, hypertension and occasionally, pulmonary oedema. Naloxone may precipitate ischaemia or acute myocardial infarction in patients with coronary disease. Doxapram is a nonspecific respiratory stimulant, which acts via chemoreceptors and thereby increases the tidal volume and the respiratory rate. It is useful in the management of respiratory failure associated with hypercapnia.[1,2] Doxapram may be useful in patients who develop CO_2 retention after epidural narcotics while adequate levels of analgesia are preserved.

Six hundred patients admitted to the Intensive Care Unit after thoracoabdominal, or abdominal cancer surgery received epidural morphine for pain relief. Thirteen of these patients developed hypercarbia (defined as a $P\text{CO}_2$ greater than 6.0 kPa and respiratory rate less than 8/minute). A doxapram infusion was titrated in these patients at a rate of 1–2 mg/minute for the entire treatment period up to 3 hours after the epidural morphine was stopped.

The average age was 56 years old. The total dose of epidural morphine was 17 mg given over 14 hours before respiratory depression was diagnosed. The mean pretreatment $P\text{CO}_2$ levels was 6.8 kPa. All patients experienced reductions in $P\text{CO}_2$ to levels below 5.8 kPa and the respiratory rate exceeded 14/minute. The mean $P\text{CO}_2$ reduction was 1.5 kPa (one-tail t-test $p<0.01$). Pain relief was maintained in all patients. There were no clinical cardiovascular or CNS side effects.

The stimulatory action of doxapram on the respiratory centre and the peripheral chemoreceptors make it a useful drug in the ICU. It also increases the diaphragmatic activity which is useful in prevention of basal atelectasis. Doxapram may have a role in the treatment of hypercapnia associated with epidural narcotics, but severe hypercarbia associated with haemodynamic changes requires that tracheal intubation and mechanical ventilation be instituted.

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The requirement for intensive care support for the pregnant population

The article by Graham and Luxton (*Anaesthesia* 1989; **44:** 581–4) was interesting.

The intensive care unit here is the only one in Glasgow with an obstetric unit in the same grounds. The admission rate for obstetric cases is very similar to that in Nottingham, 11 admissions out of just under 11 000 deliveries in a 5-year period, a rate of 1 admission per 1000 deliveries.

The reasons for admissions, however, were different. Three patients had a post partum haemorrhage, two puerperal sepsis, two varicella pneumonia, two surgical conditions which required delivery at the time of surgery, one had a placental abruption and one a ruptured uterus. One of those patients died of intractable multisystem failure after varicella pneumonia. The different admission pattern from that in Nottingham may be due to chance in the light of the small numbers involved. The fact that we had no admissions as a result of anaesthetic reasons could be because 80–90% of Caesarean sections are conducted under regional anaesthesia. The only death we had was due to varicella pneumonia. This is reported to be particularly dangerous during pregnancy,[1] a fact which still seems not widely realised since the just-published Scottish report on Maternal Mortality[2] classifies the death due to varicella pneumonitis as 'fortuitous with the outcome uninfluenced by the presence of pregnancy'.

Our experience and that in Nottingham reinforces the desirability of Maternity Units located in the grounds of hospitals with a general ICU, since an admission rate of one patient per 1000 deliveries means that there will be little experience of dealing with patients who need intensive care if they are in isolated maternity units.

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Drs Graham and Luxton report that approximately one Intensive Care Unit admission may be expected for every 1000 obstetric deliveries in Nottingham (*Anaesthesia* 1989; **44:** 581–4).

Our own experience in a newly opened teaching hospital obstetric unit reveals a greater frequency of ICU admission. Thirty-nine obstetric patients were admitted to the Intensive Care Unit with two maternal deaths during the first 2 complete years since the opening of the Homerton Hospital in East London (City and Hackney Health District); in the same period there were 7148 deliveries. This is approximately 5 times the frequency of ICU admission quoted by the Nottingham group even though the justification for such admissions were broadly comparable (Table 1).

There are several reasons for the increased rate of admission. There is a higher incidence of hypertensive disease in pregnancy which may be related to a high proportion of ethnic minority groups and patients of low socio-economic status in our local population. Such patients do not necessarily present themselves for routine antenatal care. Pre-eclampsia and eclampsia are still the most important obstetric causes of maternal mortality in the Western world, including the United States,[1] and England and Wales.[2] Fulminant pre-eclamptic toxaemia is indeed implicated in one of our maternal deaths. We follow a pre-agreed protocol for the management of pre-eclampsia and eclampsia which includes ICU admission whenever invasive cardiovascular monitoring or ventilatory support is deemed appropriate. Continuous cardiovascular monitoring is desirable when vasoactive drugs (hydralazine and phenytoin) are infused intravenously. Invasive central venous pressure monitoring facilitates management of fluid balance in the oliguric patient. Continuous assessment of respiratory and neurological status is possible only with trained staff specifically designated to care for one patient. Close observation should extend into the postpartum period since postpartum eclampsia usually occurs within 24 hours of delivery,[3] but may nevertheless present after 48 hours or later.[4,5] We currently give prophylactic phenytoin to those women at risk.[6]

Table 1. Reasons for pregnancy-associated ICU admission, and deaths associated with these admissions.

Cause of ICU admission	1987 admissions (number of deaths)	1988 admissions (number of deaths)
Hypertensive diseases of pregnancy	11	10 (1)
Haemorrhage	4	4
Anaesthesia	0	1
Others		
Amniotic fluid embolism	1	0
Left ventricular failure	1	0
Sickle cell disease	1	0
Pre-existing malignancy	1 (1)	0
Small bowel infarction	1	0
Abdominal wound abcess	1	0
Hepatocellular dysfunction	1	0
Thyrotoxicosis	0	1
Mycoplasma pneumonia	0	1

We readily admit to our unit unstable bleeding patients, for whom ICU can provide facilities for invasive intravascular monitoring of the cardiovascular system and ventilatory support; and similarly obstetric patients with severe coexisting illnesses.

Women with complications of pregnancy should be managed as other patients with similar life-threatening conditions. Treatment protocols for such medical or surgical problems regularly involve access to sophisticated monitoring equipment and 1:1 trained nurse to patient care. Currently such equipment and uninterrupted medical and nursing supervision may only be possible in an ICU-like environment. More frequent ICU admission than the Nottingham group suggest may therefore be warranted for obstetric patients with pregnancy-associated emergencies.

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Transport of ill patients

The report from the King's Fund panel on intensive care in the United Kingdom (*Anaesthesia* 1989; **44:** 428–31) expressed concern about the cost-effectiveness of small intensive care units and reiterated the need for regional intensive care services. Accurate monitoring during transport is essential if deterioration during the transfer of critically ill patients to such units is to be avoided. Few ICUs in Britain have portable direct blood pressure monitors and British correspondents continue to question the feasibility of monitoring BP in a moving ambulance.[1] We here report our experiences with the technique to highlight its practicality.

The secondary transport team attached to this hospital has monitored blood pressure directly during transfer since 1975. The technique was employed in 322 interhospital transfers, the 3 years 1986 to 1988; this represented 86% of all transfers during that period. Three hundred and thirteen transfers were by ambulance and nine by fixed-wing aircraft. Cannula sites in recent studies of indirect BP measurement in 67 patients included the radial artery (48 patients), brachial artery (eight patients), femoral artery (five patients) and dorsalis pedis artery (six patients). All proved satisfactory.

The components of our system are 150 cm manometer tubing, disposable Gould transducers and a Simonsen and Weel Diascope 2 monitor. A previous report from this hospital[2] has shown that the performance characteristics of this system allows the accurate representation of even demanding waveforms if an 'impedance matching' system ('Accudynamic', Sorensen Research Co, Utah) is used. Therefore, on each transfer the system is zeroed frequently and dynamic testing performed to ensure that the damping factor may be adjusted appropriately.

We have used such measurements to assess the variability of blood pressure in 31 critically ill patients. Frequency of measurement was dictated by the need for therapy and was therefore not uniform. The highest frequency was one reading per 1.6 minutes, the lowest, one per 16.1 minutes with the median 3.7 minutes. The standard deviation (SD) about the mean of readings for each patient served as an index of BP variability and results are illustrated in Table 1. The most appropriate comparison in the literature on BP variability is a study by Littler *et al.*[3] who continuously recorded direct arterial pressure in 10 unrestricted outpatients, awake and asleep. The actual pressure ranges in Littler's study were 79–216 mmHg (systolic) and 44–126 mmHg (diastolic) with comparable figures in our study of 94–196 and 38–99 mmHg, respectively. Variability would be expected to increase during transport, but in our transported patients it is comparable to that of Littler's outpatients.

Table 1. BP variability as represented by standard deviations and range (mmHg).

	Present study	Littler *et al.*	
		Awake	Asleep
Systolic	6 (0 to 14)	19 (13 to 29)	10 (7 to 17)
Diastolic	4 (1 to 13)	12 (9 to 22)	7 (5 to 16)

We suggest that direct blood pressure measurement in ambulances is accurate and that its more widespread use is both feasible and desirable.

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Intensive care

The report from the King's Fund panel on Intensive Care in the United Kingdom (*Anaesthesia* 1989; **44:** 428–31) is a valid and important contribution to the debate on the provision of these services, and reflects the knowledge and experience of the panel. However, some aspects of the report cause me great concern and deserve comment.

Firstly, the report implies that intensive care is a specific type of treatment rather than a range of treatments provided by doctors and nurses with a particular interest in the care of the critically ill, despite one statement to the contrary. To undertake a cost benefit analysis on intensive care as a whole would be rather like undertaking a similar study of, for example, cardiology or vascular surgery. There is an enormous amount of research into the values of different forms of treatment in different conditions in intensive care units although most of us involved would agree that some treatments are not infrequently inappropriate.

My greater concern follows on from this. The suggestion that intensive care provision should perhaps be concentrated in a smaller number of units has a certain appeal, particularly to our management colleagues, who might see the opportunity to remove an expensive area of care from their hospitals. The implications for this are enormous. Few would argue that most District Hospitals require some form of special care area, whether this be described as a high dependency unit or an intensive care unit. In any hospital that has an Accident and Emergency department and undertakes a wide range of elective and emergency surgery, particularly vascular surgery, this area will need to have facility for artificial ventilation, provide invasive cardiovascular monitoring, including pulmonary artery catheterisation, and perhaps haemofiltration. It would obviously be unwise and unnecessary to provide some other facilities in all units, for example, intracranial pressure monitoring or haemodialysis facilities. The transfer of critically ill patients requires additional staff and a considerable amount of equipment which are certainly not available at present in most health districts in the UK.

The King's Fund report should therefore be seen as the beginning rather than the end of a debate, and before districts decide that they no longer need an intensive care unit they should discuss this in detail with those who use and provide the service.

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Aneurysm formation after central venous cannulation

The case report of Huddy *et al.* (*Anaesthesia* 1989; **44:** 588–9) prompts us to report a similar complication after internal jugular venous cannulation.

A 14-year-old girl was admitted to the Regional Burns Unit after a house fire in which she sustained 65% burns to her trunk, limbs and face; fractures of her right wrist and tibia; compression fractures of T_{6-8} and T_{12}, and serious pulmonary damage from smoke inhalation. Her treatment consisted of analgesia and fluid replacement for her burns, external fixation of her long bone fractures and controlled ventilation of her lungs for 12 days. She developed meningitis 3 weeks later complicated by hydrocephalus which required to be drained in the Regional Neurosurgical Unit. Central lines were used on three occasions to aid fluid management and administration of drugs, two in the Burns Unit and one in the Neurosurgical Unit. A line was discontinued after 7 days because it was described as having 'tissued' in the early period. Two central lines were used during and immediately after her meningitis, one for a period of 8 days. A new line was then inserted but did not function satisfactorily and was removed after 2 days.

She was anaesthetised 4 months after her admission for a routine change of dressing. It was routine to change her tracheostomy tube if required while she was still anaesthetised at the end of the procedure. On this occasion, when the tube was removed, much to the consternation of everyone present, a fountain of bright arterial blood gushed forth from the tracheostomy. The bleeding stopped immediately on re-insertion of the tube.

The bleeding recurred intermittently, so a consultant cardiothoracic surgeon was called, who proceeded to median sternotomy. A pulsatile mass was identified in the mediastinum surrounded by fibrous tissues. Further exploration revealed this to be an aneurysm of the innominate artery which had eroded the trachea to produce a 2-mm wide arterio-tracheal fistula which was abraded by the tracheostomy tube.

The operative field suddenly filled with arterial blood during further dissection. The inflation pressures rose, and blood poured from the patient's nose, mouth and tracheostomy. Suction only resulted in the field refilling. Efforts to locate the source of the haemorrhage revealed that the aneurysm had ruptured; ligation was necessary and fortunately, good retrograde flow was observed in both the subclavian and common carotid arteries.

Her medical and nursing notes do not record whether on any occasion the central venous cannulation was complicated by arterial puncture, or whether any difficulty was experienced in inserting the line itself. Indeed, on one occasion, the site of cannulation is not recorded.

Should it not now be routine practice that the site of cannulation be recorded, whether puncture at any other site was attempted and subsequently abandoned, whether any difficulty was encountered with the actual insertion of the line, whether arterial puncture occurred, and as concluded by Huddy *et al.*, complications actively sought before such a potentially disastrous situation such as the one described above takes place?

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Muscle spasticity

Muscle spasticity and tremors occur during recovery from general anaesthesia, especially after halothane and other halogenated ethers.[1] They are unpleasant and can be painful. They may cause hypoxaemia.[2]

Doxapram is a respiratory stimulant with minimal actions on other systems. It has been used to reduce the incidence of postoperative pulmonary complications after major surgery.[3] The author noticed while using the drug for this purpose that muscle tremors and spasticity were prevented or stopped. The following trial was performed after approval by the South Cleveland Ethics Committee.

One hundred and sixty patients aged from 14 years upwards for ophthalmic or ear, nose or throat operations were placed randomly into two groups: the doxapram group and the control group. Patients in the doxapram group were given doxapram 1 mg/kg as a fast bolus injection over 10–15 seconds just before extubation or withdrawal of the inhalational anaesthetic. Patients in the control group were given similar anaesthetics without the doxapram injection.

All the patients were observed in the recovery ward by trained nursing staff who did not know into which group the patient had been placed. The development of muscle spasticity or tremors, nausea or vomiting and cyanosis from any cause such as breath holding, spasm or ineffective coughing after extubation or later in the recovery ward were recorded.

Patients in the doxapram group comprised 40 female, 40 male: average age 48.5 years: mean duration of anaesthesia 32.2 minutes. Forty-six were given halothane and 34, enflurane. Eight patients vomited, two developed cyanosis and one shivered. Patients in the control group: 40 female, 40 male: average age 48.5 years: mean duration of anaesthesia 32.9 minutes. Forty were given halothane and 40 enflurane. Five patients vomited, 14 developed cyanosis and 13 shivered.

Those patients who shivered were watched for 3 minutes to confirm that it was a significant complication and they were then given doxapram 1 mg/kg. All these patients stopped shivering as soon as hyperpnoea began. The shivering never recurred. Routine blood pressure measurements caused no concern. One patient complained of headache and two of dyspnoea. These patients were given the doxapram while conscious.

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Oxygen concentrators and water

The article about the versatility of the anaesthetic machine in use in Malawi by Dr P.M. Fenton (*Anaesthesia* 1989; **44:** 498–503) was interesting. The discussion about water condensation within Rotameters suggested that although this did not occur in the oxygen Rotameter it was probably due to the water being absorbed by the xeolite granules.

The main oxygen supply at the Kathmandu Children's Hospital, Nepal, was from a Japanese built oxygen concentrator; this served the whole hospital through pipelines. We measured the $F\text{IO}_2$ on the anaesthetic machine in theatre at the start of each operating list, and from April till the end of October it was always above 0.90. A month after the monsoon rains had finished there was a 24-hour deluge, worse than at any time in the preceding months, and afterwards the $F\text{IO}_2$ decreased to 0.35 where it remained till a Japanese engineer improved it to 0.70.

The engineer's findings are not known to me but, on reading about molecular sieves since my return to the UK, I am convinced that water contamination was the probable culprit.[1] Water is a competitive poison within the xeolite columns, and dry air must enter the pressure swing adsorber cycle. It was a surprise to read that only one machine had needed to be serviced at an $F\text{IO}_2$ of 0.80, and that the other machines had maintained their expected oxygen delivery.

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A reply

This is an important point; the draft regulations concerning Transoxycons (as transportable oxygen concentrators are now to be known) are that the machine shall meet ISO specifications for humidity extended to an upper limit of 100% relative humidity at 40°C.

Such extreme conditions can occur in Malawi in some locations, but as the Simonsen and Weel project took no account of the effect of water vapour (so far as I am aware) I doubt if their measurements of $F\text{IO}_2$ can be correlated with any measurements of ambient humidity, though, like Dr Carter, I did not have access to their findings.

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An unusual complication of varicose vein surgery

A fit 41-year-old woman, who weighed 64 kg and was assessed to be ASA 1, presented for high tie, stripping and multiple avulsions of varicose veins in the left leg. Oral premedication was with ranitidine and metoclopramide; anaesthesia was induced with thiopentone 300 mg and fentanyl 0.075 mg, and maintained with 1–2% enflurane and 65% nitrous oxide in oxygen. Surgery proceeded uneventfully, with electrocardiographic monitoring which indicated sinus rhythm at a rate of 70–75/minute.

The patient suddenly developed a nodal bradycardia of 35 beats/minute towards the end of the procedure. This coincided with the application of firm pressure to the patient's groin; cessation of pressure was associated with immediate resumption of sinus rhythm at 65/minute.

Repeated application of direct surgical pressure over the femoral artery caused nodal bradycardia of 20 beats/minute, which spontaneously reverted to sinus rhythm at 70 beats/minute when pressure was removed. Surgery was completed uneventfully without further alteration in heart rate or rhythm. The patient made an uncomplicated recovery and was discharged home the next day.

It is well known that baroreceptors are present in the large arteries of the thorax and neck,[1] and carotid sinus massage is used successfully to terminate supraventricular tachycardia.[2] It appears that a similar mechanism was responsible for the short-lived but profound bradycardias which occurred in our patient, after direct pressure over the femoral artery in an open wound.

Many patients are subjected to application of firm pressure to the groin without ill effect after diagnostic procedures that involve femoral artery puncture. Nevertheless, we recommend an increased awareness of the possibility of bradycardia associated with such manoeuvres.

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Hypotension and epidural for Caesarean section

A.M. Murray *et al.* (*Anaesthesia* 1989; **44:** 463–6) state that there is little benefit from the use of an incremental epidural technique in relation to the incidence of hypotension. They quote numerous studies, to support this statement, but do not identify the local anaesthetics which were used.

We published a study[1] which compared incremental injections through a catheter, with bolus injections through a needle, for elective Caesarean section using lignocaine hydrochloride with freshly added adrenaline. We used 1500–2000 ml of lactated Ringer's solution as preload and displaced the uterus. We found a significant difference between the two groups with regard to the incidence of hypotension (13.6%:52.2%; $p=0.014$). We found a higher quality of anaesthesia in the incremental group.

The incidence of hypotension reported in the literature varies according to the volume of preload, the extent of epidural block and the presence or absence of labour. Our data suggest that the speed of injection is an important factor in the occurrence of this complication.

The studies quoted did not compare the two techniques and, apart from this, it is important to know which local anaesthetic was used, the speed of injection and also whether patients were in labour. A slow onset of the sympathetic block allows for haemodynamic compensation and, consequently, incremental injection through a catheter is safer in all pregnant women. Additionally, in theory, the risks from inadvertent intravenous or subarachnoid injection would be lessened.

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Recovery from two different intravenous induction techniques in identical twins

The opportunity occurred recently to compare two different methods of intravenous induction in a pair of identical 7-year-old girls, who presented consecutively for repair of inguinal hernia. They both weighed 23 kg and were unpremedicated save for EMLA cream on the dorsum of the left hand.

Anaesthesia was induced in the first child with thiopentone 150 mg, and maintained with nitrous oxide, oxygen and halothane plus ilio-inguinal block with 5 ml 0.5% bupivacaine. The second child received alfentanil 3 μg/kg before propofol 70 mg (3 mg/kg); an identical sequence for maintenance then followed.

Both procedures lasted less than 15 minutes, and spontaneous eye opening was recorded at 20 and 35 minutes respectively after entry to the recovery room. The twin who received alfentanil/propofol was reported to be more subdued on the ward later on, nonetheless both children went home within 3 hours of operation.

Propofol is advocated in preference to thiopentone for rapid recovery in children.[1,2] The combination of alfentanil and propofol is popular for adult day cases,[3] and alfentanil appears to be eliminated more rapidly in children.[4]

This is hardly a controlled clinical trial, but I was surprised at the outcome and wonder whether a formal trial would be worthwhile as these twins may not be representative of children in general. How often do identical twins appear consecutively on the operating list for identical procedures?

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Misassembly of Laerdal masks

Our recent experiences with Laerdal masks have prompted us to point out possible hazards after their incorrect assembly after cleaning. On several occasions the stud at the nose end has not been replaced. This produces a small leak, usually easily detected and stopped by thumb or by applying tape.

A potentially more serious problem may occur, which is illustrated in the Figure. The soft cushion, which should be inside the harder shell, as shown by the mask on the left, can be placed outside the shell, as shown by the mask on the right. This incorrectly assembled mask allows a large leak which makes ventilation of the lungs impossible. The cause of this leak is not apparent immediately, on superficial examination of the mask, by someone not familiar with it.

We have found the mask excellent in use apart from these problems and a great improvement on nontransparent rubber masks.

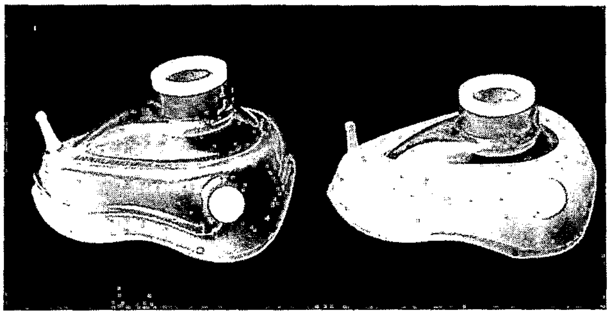

Fig. 1.

The manufacturers stress the importance of correct assembly of the mask after cleaning and provide clear illustrated instructions which are helpful. However, these instructions may not be followed or may be unknown and it is because of the possibility of incorrect assembly that we have written.

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A reply

We are very surprised at this report. We have never heard of this happening before and there are hundreds of thousands of these masks in use worldwide.

We accept that it is possible to put the mask together in this way, but it can only be done with excessive force and by a person with no understanding of the product. The Department of Health has stressed on a number of occasions the importance of staff training: instructions must be known and followed by those who take apart and reassemble emergency equipment. We provide, as Dr Wright points out, clear and widely available instructions to facilitate this.

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Abolition of injection pain due to propofol in children

Studies of propofol for the induction of anaesthesia in children show that the incidence of pain on injection is high especially when veins on the dorsum of the hand are used. The current recommendation of additional lignocaine, 10 mg to each 200-mg ampoule of propofol is not nearly as effective in the reduction of pain on injection in children as it is in adults. Up to 60% of children aged 1 to 10 years still have pain on injection into the veins of the dorsum of the hand when this regimen is used.[1-3] A higher dose of lignocaine has proved to be very effective.

In 50 unpremedicated paediatric day cases, aged 1 to 10 years, 2% lignocaine 1 mg/kg was mixed with propofol 3 mg/kg in the syringe immediately before administration via a 25-gauge butterfly in a vein on the dorsum of the hand. No patients complained, or showed signs of pain, on injection.

It is important to add the lignocaine to the syringe immediately before administration rather than to the ampoule at the beginning of the list because its efficacy is lost after 30 minutes.[1] This is particularly important when using propofol in children where the 20-ml ampoule can be used as a multidose vial for up to six patients.

This simple and effective method is recommended and the table shows the volumes required.

Table 1. Dosage guide for propofol/lignocaine mixtures.

Weight (kg)	Volume of propofol to give 3 mg/kg (0.3 ml per kg)	Volume of 2% lignocaine to give 1 mg/kg (0.05 ml per kg)	Suitable size of syringe
10	3.0	0.50	5
15	4.5	0.75	5
20	6.0	1.00	10
25	7.5	1.25	10
30	9.0	1.50	10

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Perforation of oesophagus by tracheal tube during resuscitation

Perforation of the oesophagus is a rare complication of tracheal intubation and usually occurs after hasty intubation. Oesophageal perforation is the most fatal among bowel perforations and prompt diagnosis and treatment is needed for its successful management.

A 67-year-old male, who had suffered from chronic obstructive lung disease for many years, was treated with bronchodilators routinely. He developed a severe acute asthmatic attack which led to respiratory arrest. An intensive care team was summoned to the home but was unsuccessful in tracheal intubation and the patient was transferred to the emergency room. Manual ventilation of the lungs was by means of an Ambu bag and mask. Tracheal intubation was achieved after several attempts in the emergency room. The cyanosed patient was transferred to the intensive care unit in a stable haemodynamic condition (BP 100/80 mmHg, pulse 100/minute). There were diffuse inspiratory and expiratory wheezes, a prolonged expiratory phase and distant heart sounds. The abdomen was distended and tympanitic to percussion; subcutaneous emphysema appeared in the neck and chest. Pneumomediastinum without pneumothorax was seen on chest X ray and there was no free air under the diaphragm. The patient complained of pain in the neck and upper abdomen and the subcutaneous emphysema spread to the face and abdominal wall. A presumptive diagnosis of perforated oesophagus was made but the patient's ventilatory status precluded confirmation by gastrografin swallow. Treatment with broad spectrum antibiotics was started. The patient was ventilated using intermittent mandatory ventilation at 11/minute ($F\text{IO}_2$ 0.8). Arterial blood gas analysis revealed a $P\text{O}_2$ 16.9 kPa, $P\text{CO}_2$ 6.9 kPa, pH 7.28. The respiratory condition improved and allowed extubation on the second day. A gastrografin swallow showed a high oesophageal leak to the mediastinum. This was drained under general anaesthesia and the leak disappeared after 3 weeks. He was discharged in good condition 30 days later.

Difficult intubation may be a cause of haematoma in the posterior pharynx or oesophagus. Instrumental perforation of the oesophagus is the most common cause of such injuries and accounts for 75% of cases.[1] Tracheal and nasogastric intubation cause a similar frequency of perforation,[2] but the most prevalent instrumental perforation is during endoscopy. Perforation of the cervical oesophagus is usually in the area of the cricopharyngeus muscle posteriorly where there is a lack of the longitudinal muscle. Pain is the prevalent symptom and is related to the area of perforation. Other common signs are subcutaneous emphysema and cyanosis. Plain chest films and cervical films may show subcutaneous emphysema, pleural effusion, pneumomediastinum and pneumothorax.[3]

The management of this high oesophageal perforation should include broad spectrum antibiotics and surgical drainage and repair by a cervical approach. The efficacy of treatment should be measured not only by the mortality rate but also by morbidity. Mathewson[4] found in 51 cases that the recovery was more complicated and longer in cases that were managed conservatively, and he emphasised the point that more 'aggressive' surgical treatment would reduce the mortality rate as well. Nealon[5] claimed that surgical treatment should be in the first 24 hours after perforation to reduce mortality and morbidity.

Whenever perforation of oesophagus is suspected, contrast X ray will establish the diagnosis, and prompt surgical treatment is mandatory.

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Awake blind nasal intubation: use of a simple whistle

Use of the blind nasal route to facilitate intubation of the anaesthetised patient is well described.[1,2] The method is easy to learn, but the technique is prescribed in patients at risk from aspiration of gastric contents. This limitation can be circumvented by using the method in the awake patient, especially when aided by a specifically designed whistle placed on the end of the tracheal tube. There are a number of descriptions to aid awake blind nasal intubation;[3] this method has the advantage of simplicity. It is in common usage by anesthesiologists in Texas, with a high success rate.

The patient is lightly sedated with small increments of midazolam or fentanyl intravenously after a careful explanation. Vasoconstrictor and local anaesthetic are applied sequentially to the right nasal passages (we recommend any proprietary vasoconstrictor and 4% cocaine paste). Increasingly large nasal airways coated with 5% lignocaine gel are then passed to dilate the nasal passages. A standard Portex tracheal tube is inserted until it is judged to lie in the posterior nasopharynx. Anaesthesia to the vocal cords and upper airway can be achieved by either transtracheal injection of 4 ml of 4% lignocaine, or just as easily by forceful injection of 4 ml down the tracheal tube. For this latter technique a 10-ml syringe filled with local anaesthetic plus 6 ml air is ideal. Oxygen can be administered via a nasal cannula to the left nostril, if appropriate.

The whistle is attached to the connector after a 30-second pause and the tube advanced, with the head extended and neck flexed. As the tip approaches the glottic opening inspiration becomes audible through the whistle increasing in volume until, as the tube passes through the cords, continuous loud whistling occurs and the patient can no longer speak. Should the tube migrate into the oesophagus whistling will cease. Deviation from the midline can be readily detected by observing the soft tissues of the neck as the whistling decreases. The patient can be asked to adjust the position of the head, if necessary.

The technique is cheap, reliable and very easy to learn (first year residents quickly take to it). In addition to being as readily applicable to the patient who is at increased risk of aspiration as fibreoptic intubation,[4] the method offers other advantages. Firstly, the procedure does not require the consistent practice and steep learning curve of the fibreoptic device. Secondly, in contrast to a rapid sequence induction, the technique can easily be abandoned if unsuccessful. Furthermore because of the avoidance of general anaesthetic agents which might depress the cardiovascular system it may be applicable to the intensive care environment.[5] The whistle has also been recommended for nasal intubation of the anaesthetised, spontaneously breathing child since it requires a maximal inspiratory flow rate of only 50 ml/second to produce an audible tone.[6] Some anesthesiologists use the whistle to guide the nasal tracheal tube into an optimum position before passing a fibreoptic device.

The whistle itself is a modification of the Waldhaus Tracheal Indicator (Fig. 1) and is readily available as the Beck Airway Airflow Monitor from Great Plains Balistics Inc., P.O. Box 16385, Lubbock, Texas 79490. Alternatively an effective (inspiration only) whistle can be constructed by modification of a Mallinckrodt 3.5 mm tracheal tube connector and a suitable 15-mm male-to-male adaptor (Fig. 2).

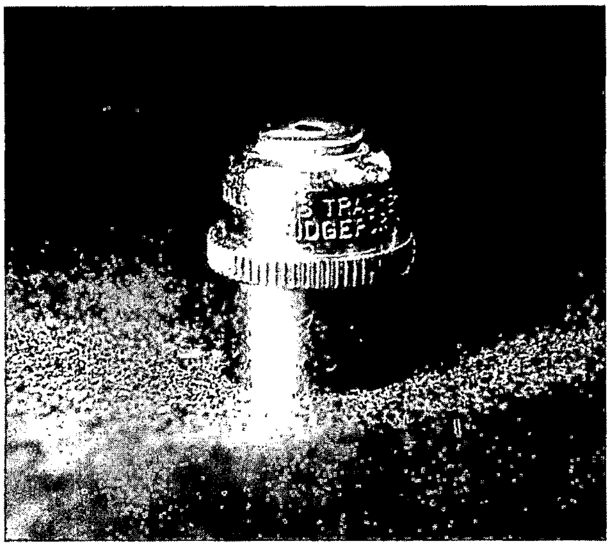

Fig. 1.

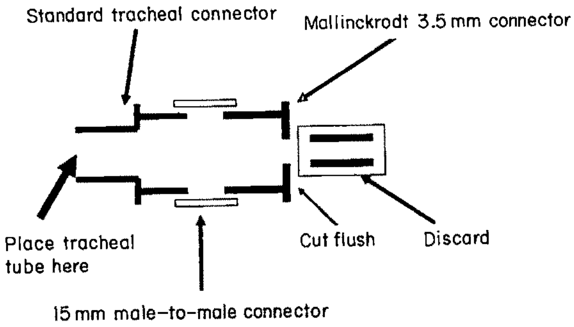
Standard tracheal connector
Mallinckrodt 3.5 mm connector
Place tracheal tube here
Cut flush
Discard
15 mm male-to-male connector

Fig. 2.

The University of Texas A. Dyson
South Western Medical Center, P.R. Saunders
Dallas, A.H. Giesecke
Texas, USA

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A self-retaining nasopharyngeal airway

Brain[1] recently described the laryngeal mask as a novel method to maintain an airway. We wish to describe our early experience using an alternative device which is also effective during spontaneous ventilation. It consists of a cheap disposable cuffed nasopharyngeal tube, which rests in the pharynx above the larynx. We used a red rubber nasotracheal (Leyland) tube at first then a 7.5-mm oral profile cuffed (Portex) tube and more recently a specially constructed tube was produced by Portex from ivory polyvinyl chloride (pvc) with a 7.5-mm internal diameter and a profile cuff.

The prototypes of this device were used to maintain the airway in 70 anaesthetised patients during spontaneous ventilation, the last 26 patients had the specially constructed tube. Patients with a deviated nasal septum, haemorrhagic disorders or concurrent anticoagulant therapy were excluded from this study. Anaesthesia was induced in all patients after an opiate premedication with thiopentone 4–5 mg/kg. Maintenance was with nitrous oxide, oxygen and a volatile agent with the patient breathing spontaneously. A well lubricated tube was blindly inserted through the nostril until the tip rested in the oropharynx behind the tongue when surgical anaesthesia was attained. Successful placement was indicated by conduction of breath sounds down the tube. The cuff was then inflated with 15–30 ml of air to displace the tongue from the posterior pharyngeal wall (Fig. 1). The patency of the airway was confirmed by observation of the reservoir bag and capnography. The distance from the tip of the tube to

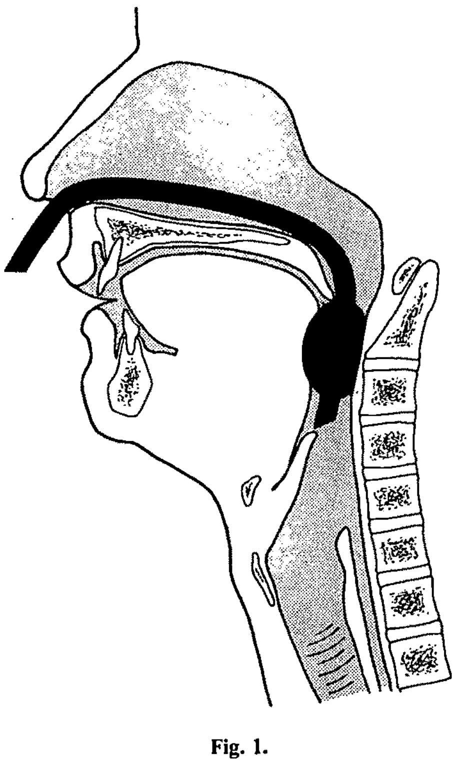

Fig. 1.

the nostril was measured in each case. The quality of the airway was assessed as clear, partially obstructed or obstructed and any other complications noted.

The airway was used successfully in 64 (91%) patients and a clear airway was easily maintained. In two patients there was partial obstruction which was relieved by manually lifting the jaw. Of the total of 70 patients, four (5.7%) needed intubation. Three of these had laryngospasm caused possibly by mucus and blood in the pharynx. One had partial obstruction which was unrelieved by positioning.

The average tube length was 16.25 cm (SD 1.2). Initially there were some problems on introduction of the tube, with laryngospasm in five (7%) cases. This was as a result of placement of the tube before the patient was adequately anaesthetised, insertion of a tube which was too long, or nasal bleeding.

Minor bleeding occurred in six (8%) patients (mainly small females with modified tracheal tubes) whilst clinically insignificant blood streaking of the tube was noted on removal in 16 (22%) patients. This incidence of epistaxis is comparable to that seen with red rubber airways.[2] The small incidence of bleeding may be because the 7.5-mm nasal tubes were too large for most patients. The use of smaller tubes made of soft ivory pvc combined with the routine use of a topical vasoconstrictor has reduced the incidence of nasal bleeding in subsequent patients.

The simple manoeuvre of inflation of a cuffed tube within the pharynx appears to function effectively as an airway during spontaneous ventilation. An evaluation is in progress to determine whether the specially constructed tubes will reduce the already small incidence of side effects.

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N.O. Boheimer
S.A. Feldman
N. Soni

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A CPAP silencer

The process of weaning a patient from artificial ventilation can be difficult and prolonged. It may be facilitated by the use of continuous positive airway pressure (CPAP), and we have found the System 22 CPAP Downs adjustable flow generator 9250 (Vital Signs Inc) to be useful.

However, like most CPAP systems a certain amount of unwanted noise pollution is generated. The operating noise of this system has not proved to be unduly disturbing to our patients or staff, but occasionally there has been an additional noise problem which has proved irritating to all. A loud musical sound with an undulating pitch (resembling the waveform of simple harmonic motion) has occurred in time with the patient's breathing cycle. By experimentation with the generator flows, valve orientation and connecting tubing we have found that the problem is caused by the inner surface of the connecting tubing used on our unit (Hudson disposable corrugated tubing, 1680). If the expiratory limb, from the tracheal tube to the CPAP valve, is replaced with tubing of smooth internal surface then this irritating undulating sound is either removed or significantly reduced in intensity. This simple solution has restored some tranquility to our patients and nurses but has removed an unusual long-distance audible respiratory monitor.

West Suffolk Hospital,
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N.W. Penfold
S.S. Lowe

Bain system for use with a circle absorption system

The letter from Dr Kumar about the use of the Bain system to replace the breathing hoses of the circle absorption system (*Anaesthesia* 1989; **44:** 791) was interesting. The flow of gases through the narrow inner tube of the Bain system is not intended to be driven by the patient's respiratory efforts; it seems likely that when used in this way in the spontaneously breathing patient it would present a large resistance to inspiration.

The resistance to constant gas flows was measured in three coaxial and one parallel commercially available modified Bain systems, using air at room temperature supplied from a domestic vacuum cleaner. Flow rates were measured by a Rotameter (Rotameter Mfg. Co. Ltd., England) and the pressure drop across the inner tube of the Bain system measured with a water manometer.

The pressure drops at each flowrate varied widely but consistently with each individual circuit; at 10 litres/minute they varied between 0.38–0.9 kPa; at 15 litres/minute, 0.95–1.9 kPa; at 30 litres/minute the parallel circuit showed a pressure drop of 2.1 kPa; at this flowrate all the coaxial systems showed a pressure drop of greater than 2.4 kPa. Interestingly, at each flowrate the parallel system showed the lowest resistance.

These resistances are greatly in excess of those suggested by Nunn[1] as the upper limits of acceptable resistance for an adult, and so I attempted to breathe through a system constructed as described by Dr Kumar. The inspiratory resistance became intolerable after 20–30 seconds even during quiet breathing, while active breathing was impossible due to the restriction of inspiratory flow.

It is known that anaesthetised patients may overcome quite large increases in resistance by augmentation of inspiratory muscle activity and increasing the work of breathing. The response under anaesthesia is probably driven largely by an increase in arterial $P\text{CO}_2$. Dr Kumar may have observed this phenomenon in his patients, in which respiratory rate, end-tidal carbon dioxide, heart rate, blood pressure and oxygen saturation were recorded while breathing first from his system and then from the standard Bain attachment. It would be surprising if patients breathing from the system described had not shown elevated end-tidal $P\text{CO}_2$ levels but we are not presented with the data. The fact that Dr Kumar has not been able to show a statistically significant difference merely allows the null hypothesis of no difference between the system to stand until otherwise disproved, and may obscure real and important differences in the data collected under the two conditions. This can hardly condone the imposition of unnecessary extra resistance in the breathing system. Measurement of inspiratory flowrates and inspiratory:expiratory ratios in Dr Kumar's patients may have revealed the degree of the burden put upon them. I would not be happy to use this system for any of my patients during spontaneous ventilation.

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G.J. Hale

References

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Damage to Manley ventilators

We wish to report two similar incidents which we have encountered with Manley MP3 ventilators.

On the first occasion the MP3 was on the bottom shelf of an anaesthetic machine. It was dislodged by pulling on the tubing from the patient end and fell to the ground. It was brought back into service and used by three anaesthetists for five cases after a thorough check by the anaesthetist and ODA. Subsequently it was again used by the original practitioner for an operating list. The ventilator was heard to stop cycling as reversal agents were being given. Inspection revealed grossly overdistended bellows (Fig. 1). The controls were switched to manual and the anaesthetic concluded without further incident. Subsequent inspection revealed that one of the top rack retaining pillars was distorted (Fig. 1, A) and that the top rack assembly had consequently moved out of position allowing the tidal volume catch to miss the mechanism trip lever (Fig. 2, B).

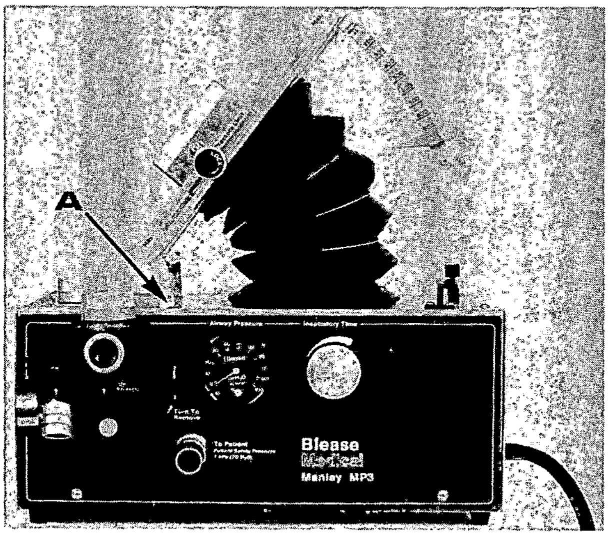

Fig. 1.

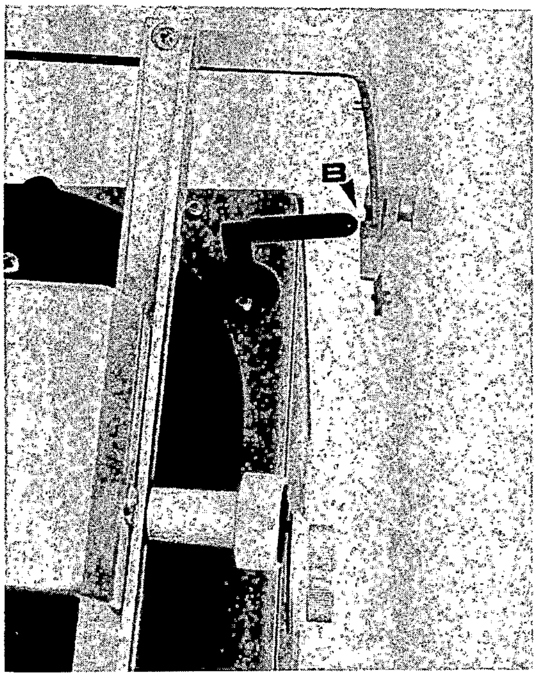

Fig. 2.

The incident was presented at a departmental morbidity and mortality meeting. Shortly afterwards one of us (S.G.T.) was anaesthetising a patient at another hospital in the group and noticed that the top rack retaining pillar was developing a similar distortion and that the tidal volume catch was only just contacting the trip level. It was very easy to reproduce the first incident after the anaesthetic. There was no history of the second machine having suffered accidental damage.

Each top rack retaining pillar is held only by a single screw from below. It may be advisable to consider whether this represents a weak point in the design of the ventilator.

Detection of the problem was rapid, when the first incident occurred, because of the altered auditory input noted by the anaesthetist. No harm came to the patient since the machine stopped in expiration. Increasing pressure in the bellows was not therefore transmitted to the patient. The potential danger was therefore one of apnoea.

We recommend that, in view of the incidents described, any ventilator which is accidentally dropped should be fully checked by a competent service engineer, that ventilators kept on an anaesthetic machine should be supported by a bracket or be attached to a bar, and finally that consideration should be given to the routine use of a ventilator disconnect alarm which would detect the failure of cycling in such an incident.

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J.F. Stubbing
S.G. Tordoff
M.A. Skivington

A reply

The report fault is extremely rare and could only occur in the circumstances of the machine being dropped with resultant damage to the cabinet or distortion of the tidal volume arm. There was considerable cabinet damage and the top rack retaining pillars are completely out of position. The rack assembly still operates even out of its normal position and thus allows the tidal volume catch to miss the mechanism trip level completely.

It appears there was sufficient contact between the tidal volume catch and the trip lever for the ventilator to function adequately for a time. However, every change in the tidal volume brings the risk of failure closer. It must be extremely rare for a ventilator to be returned to service without a full check and we reiterate your view that this is an essential feature of safe practice.

Service Manager,
Blease Medical Equipment,
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T. Aron

The laryngeal mask airway

We would like to recommend a situation in which the laryngeal mask airway has proved most useful. As part of the medical assessment of patients being considered for surgery for epilepsy, electroencephalographic recordings are made from the temporal lobes from electrodes passed percutaneously through the foramen ovale[1] under general anaesthesia. Mask anaesthesia is impossible for the placement of the electrodes, because the mask is in the way of the surgical procedure, and tracheal intubation is not required for a relatively short procedure. A total intravenous anaesthetic technique without a secure airway is very stressful to both patient and anaesthetist as adequate oxygenation at all times cannot be guaranteed. The ingenious laryngeal mask airway with spontaneous ventilation is now our first choice which we recommend to other workers for this procedure.

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T. Ammar
R.M. Towey

Reference

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Burns from iodine

We report two recent incidents of a complication which we have not encountered before. Each patient concerned was critically ill and had controlled ventilation of the lungs. The orotracheal tube was secured in each case with 1.25 cm cotton tape padded with foam rubber at the back of the neck. Both patients required venous access for the passage of a pulmonary artery (PA) flotation catheter and so an internal jugular approach was used with full aseptic precautions, using a povidone iodine-in-alcohol solution for skin preparation (neither patient had had a previous iodine skin reaction).

The aforementioned tape was contaminated with the povidone iodine solution. Passage of the PA catheters was uncomplicated, but because of the severity of each patient's condition, the soiled tapes were not immediately changed whilst treatment progressed. When the tape was eventually changed 4–6 hours later there were skin lesions resembling chemical burns directly underneath the contaminated tape but there was no evidence of a skin reaction anywhere else. These lesions were cleaned and dressed and in each case healed without further problems.

It is likely that the povidone iodine solution was concentrated and kept in close proximity to the skin by the tape, and this resulted in the tissue damage. We are now even more vigilant about changing any contaminated tapes or dressings, and offer these two incidents as cautionary tales to others.

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M. Joseet

The oesophageal detector device

This is a description of another use of the oesophageal detector device.

The laryngeal mask (LM), as is well known, provides a convenient channel for blind tracheal intubation but the diameter of the tube that can be used is restricted (at present) especially if it has a cuff. This can be overcome by using the LM to pass a gum-elastic bougie into the trachea then withdrawing the LM over it, and rail-roading a suitable tracheal tube over the bougie.

The problem, of course, is to be sure the bougie is in the trachea before removal of the LM. The bougie is replaced by a 16-G nasogastric tube, stiffened as is the local custom, by storage in the theatre refrigerator. This can be fitted with a 15-mm connexion of suitable size to fit onto the oesophageal detector device. The appropriate sign is readily elicited even through the narrower tube.

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B.E. Welsh

Damage to multidose vials

This is a report of a hazard of the use of glass vials sealed with a rubber diaphragm.

Ten millilitres of water were injected through the rubber diaphragm top without first withdrawing air from the vial, during reconstitution of a vial containing 750 mg of powdered Cefuroxime. The vial burst, its flat base separating from the rest of the container (Fig. 1). Fortunately, no other damage was caused.

Examination of the fragments by the manufacturer revealed that at some stage after processing, some impact damage was sustained, which weakened the vial. The injection of 10 ml of water into the vial without air withdrawal would have caused a pressure of 1.5 atmospheres above atmospheric. The weakened glass cracked and the vial exploded.

Correspondence with the drug manufacturer concerned, and other drug companies, showed that they go to considerable lengths to stress-test vials from each batch and individually inspect each vial after filling for cracks and flaws. However, impact damage during distribution and storage may occur.

It is obviously wise to examine vials of a similar design

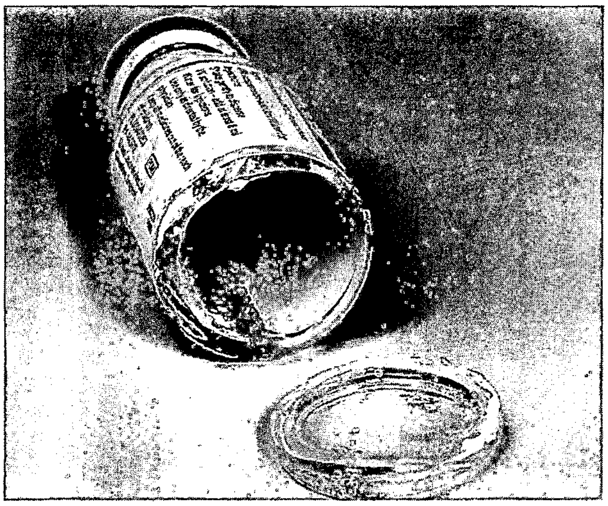

Fig. 1.

before use, and withdraw air from them before solvent injection to eliminate any danger of pressure causing them to burst.

Several other hazards from the use of glass drug containers are described, including contamination from glass fragments and pressure build-up in sealed ampoules of radionucleotides.[1,2] Discussion with colleagues has shown that this was not an isolated incident with rubber diaphragm vials; however, this hazard is not reported in the literature.

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J. Vernon

References

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2. John G. A possible hazard: pressure build-up in sealed ampoules of radionucleotides in aqueous solution. *Health Physics* 1985; **49:** 977–9.

Failed cuff deflation

The advent of disposable orotracheal tubes may tempt some to 'snap' the pilot tube in order to deflate the cuff before tracheal extubation, especially if a syringe is not available. We found in a routine extubation that pulling the pilot tube to snap it did not result in deflation of the cuff because the pilot tube sealed at the point of stretching and breakage. Hence extubation was done with the cuff inflated. Further testing of these (Sheridan) disposable tubes has shown us that nondeflation of the cuff is fairly common after the above procedure. We have heard reports of similar experiences with other types of disposable oral tracheal tubes.

There are possible complications that can arise after extubation with an inflated cuff. These include bruising of the larynx and damage to the vocal cords resulting in dysphonia and in extreme cases oedema with possible stridor and dyspnoea.[1] Stretch injuries of the recurrent nerve are reported during difficult extubations, and neuropraxias due to inflation of the cuff within the larynx both result in paralysis of a vocal cord.[1] We recommend the use of a syringe for deflation and sharp scissors to cut off the pilot tube if a syringe is not available.

Queen's Medical Centre,
Nottingham NG7 2UH
T.M. Bourne
K. Tate

Reference

1. Atkinson RS, Rushman GB, Lee JA. *A synopsis of Anaesthesia*, 10th edn.

Correction

Dr J. McWilliam has informed us that there were miscalculations in the Table that accompanied his letter (*Anaesthesia* 1989; **44:** 866). The amended version is printed below.

Table 1. Costs of anaesthetics with and without propofol.

Procedure	Average cost without propofol	Average cost with propofol	Factor: increased cost with propofol
Suction termination of pregnancy	£1.19 $n = 13$	£2.62 $n = 23$	×2.20
Cystoscopy	£1.09 $n = 16$	£2.80 $n = 15$	×2.57
Arthroscopy	£0.94 $n = 6$	£3.10 $n = 9$	×3.3

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Book reviews

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Anaesthesia and the brain

J.D. Michenfelder. Pp. x+215. Churchill Livingstone, 1989. £27.50.

It has been a delight to review Dr Michenfelder's book which has been written almost as an autobiographical monograph setting down and analysing a career's clinical experience and research findings. It has the all too rare advantage of single authorship which confers a consistency of prose which makes it easily readable; its length allows it to be skip-read in a single sitting. The aim of the book is 'to bring together all of the clinically relevant information available regarding the effects of currently used anaesthetics on the brain'. The aim has been achieved to the extent that it draws a line under what has gone before and having absorbed the contents of this book allows the enquirer to proceed, confident in the knowledge that he knows just about everything he needs to; in effect, 'new readers start here'.

The book concerns itself with functional, metabolic and vascular sequelae of various physiological and pharmacological cerebral manipulations and is organised under these three broad headings. It starts with a basic review of the awake brain which is then contrasted with the hypothermic and the anaesthetised brain. The effects of inhalational and intravenous anaesthetic agents are examined followed by local anaesthetics, muscle relaxants and miscellaneous agents including vasoactive drugs such as sodium nitroprusside, nitroglycerine and angiotensin. Drugs largely eliminated from clinical practice such as cyclopropane and those 'which may never be used' in the United States, for example sevoflurane, are deliberately excluded. Along the way we learn (or are reminded) that nitrous oxide is not the physiologically inert agent that we assume and are given the state-of-play of isoflurane as the agent of choice for neurosurgical anaesthesia. The final section of the main body of the book contains a review of methods of assessing brain function and safety and the thorny question of cerebral protection, a subject on which, on more than one occasion, Dr Michenfelder has found himself out on a limb. The final section of the book is headed 'Lagniappe' (yes, from the Cajun) and contains an unlikely pharmacological/statistical whodunit.

The index is concise but passes all tests, the references alone would make the book worth buying and if one had permission to copy the illustrations for lantern slides few would need to be added for a complete lecture course on cerebral function and neuroanaesthesia.

The book is intended for all who wish to know about the subject regardless of status or experience and its price enables it to be bought rather than borrowed. The clinical advice to be drawn from the evidence is often pragmatic (Question:— should one use nitrous oxide or not in pneumocephalus? Answer:— reduce nitrous oxide concentration to 50%). It is destined to become a standard text but, as should be stressed in all books written at the extent of knowledge in which all questions do not necessarily have answers, the author adds the caveat that the text should be read critically and assimilated selectively rather than learned by rote for regurgitation in an examination; teachers and examiners should brace themselves mentally for the flood of retorts 'that's not what it says in Michenfelder's book'.

D.A. Saunders

Medicine in the practice of anaesthesia

Edited by L. Kaufman and D.J. Betteridge. Pp. vi+361. Edward Arnold, 1989. £35.00.

A sound knowledge of medical disorders is essential to the practice of safe anesthesia. The editors have recognised the need for an up-to-date text on general medicine for the anaesthetist. They have enlisted the help of 12 specialist physicians, a radiologist and one anaesthetist to produce 10 readable and comprehensive chapters. The result is a contemporary general medical textbook but one which tends to lack insight into the anaesthetic problems generated by medical disorders. Indeed, the only advice offered to the anaesthetist in the whole chapter on neurology is that anaesthesia does not precipitate relapse in multiple sclerosis. Would it have been better for each chapter to have been co-written by a physician and an anaesthetist?

There is much to commend this book. One chapter is devoted to radiology, principally that of the chest with clearly reproduced X rays and diagrams used to illustrate the text. Another interesting chapter is that on acid/base balance, which gives a clear and graphic explanation of the disorders of acid/base and, since it is written by an anaesthetist the anaesthetic implications are well described. The chapter on rheumatic disorders is concise and contains a great deal of helpful advice about the anaesthetic management of these diseases. The interpretation of ECGs is approached from first principles which aids the understanding and diagnosis of arrhythmias. I particularly enjoyed the excellent and enlightening sections of asthma, diabetes, blood transfusion, blood products and heart failure.

Overall the book is convenient to use. Each chapter is divided into about a dozen sections which are listed in the contents. There is a comprehensive index but no cross referencing between chapters when subjects overlap. The page layout is double column and in most chapters the text is broken by useful tables and lists, ideal for examination candidates. Most chapters have a short list of references and suggested further reading.

This book will be useful for trainees preparing for Fellowship as a simple, state-of-the-art textbook of medicine. It will also be invaluable to any anaesthetist wishing to brush up on medicine or to reference a contemporary viewpoint. However, referral to another text would be required for anaesthetic management.

P.A. CLYBURN

Anaesthetic and extracorporeal gas transfer

K.L. DORRINGTON. Pp. ix+274. Oxford University Press, 1989. £35.

This book appears to be addressed primarily to biomedical engineering students since it is one of the 'Oxford Medical Engineering Series'. It is principally concerned with providing theoretical, mathematical analyses of gas exchange in medical breathing systems, vaporizers, and extracorporeal lungs. This it does very thoroughly except that sometimes the initial assumptions are too simplified to match reality. This is justifiable in an undergraduate text, where the object is largely to train students in a method of approaching problems. However, it is disappointing that there are few pointers to how more realistic assumptions could be handled and, surprisingly, virtually no mention of computer solutions.

Each chapter begins with a brief history and, where necessary for the engineering student, an outline of the relevant physiology. Indeed, chapter 1 is essentially a brief course in gas exchange in the lungs and circulation. The mathematical analyses cover rebreathing in both spontaneous and controlled ventilation (chapters 2 and 4), vaporization of liquid anaesthetics in plenum vaporizers (chapter 3), and oxygen and carbon dioxide exchange in extracorporeal lungs (chapters 5 and 6). Chapter 3 also examines the relationships between MAC, saturated vapour pressure, and oil-gas partition coefficient; and it includes a brief exploration of the pharmacokinetics of inhaled agents. Chapter 2 repeats the elegant graphical analysis of rebreathing in spontaneous ventilation which was published in *Anaesthesia* in 1987 and chapter 4 extends the analysis to controlled ventilation. That chapter also gives a mathematical explanation of how carbon dioxide can be eliminated when the tidal volume is smaller than the deadspace.

So what is in it for the anaesthetist? The preface says that 'clinicians will recognise and understand many of the solutions presented'. Well, yes, but will they want to read it? Certainly, anyone contemplating research in this area should study it. The mathematics is just algebraic manipulation, plus occasional bits of simple calculus. But some of the manipulations go on for an awfully long time. However, it is not necessary to work through the derivations: if the reader is satisfied with the assumptions on which an argument is based, he can confidently use the solutions provided. It is a pity in this respect, that the author has not distinguished, perhaps by a different typeface, the derivations from the assumptions and solutions. An important omission is a list of symbols. These are all defined when first used, but it is frustrating to look up an equation and then have to track back, perhaps through many pages, to find the definition. Each mathematical analysis is preceded by a clear exposition of the circumstances which should be helpful in clarifying any purely qualitative thinking about the problems considered. In addition there are comparisons of theory with experiment, and some interesting experimental results for vaporizers. And, of course, there are the readily understood diagrammatic and graphical analyses of rebreathing.

The illustrations are plentiful, clear, and well captioned. Tables of experimental data (e.g. MAC, molar mass, and oil-gas partition coefficient) are meticulously referenced; statements in the text are not. However, a dozen or so references for 'further reading' are given at the end of each chapter and footnotes give some one-line biographies from which we glean such gems as the full name of Avogadro: Lorenzo Romano Amedeo Carlo Avogadro di Quaregua e di Cerreto! A few spot tests on the index worked although, to find injectors, you have to look under 'entrainment' or 'oxygen masks'. The book is beautifully produced with the immaculate typesetting of equations that one expects of the OUP.

In summary, I think it will be important for anaesthetic researchers to have access to this book, but it is not an easy arm-chair read.

W.W. MAPLESON

Essentials of Critical Care Medicine

M.J. TOBIN. Pp. 578. Churchill Livingstone, 1989. £19.95.

This new compact textbook on critical care medicine has been written for the doctor in training, respiratory therapist and nursing team. It is particularly relevant for the American market because it attempts to cover the syllabus for the American certification examination in critical care medicine. It is a single author effort which has certain advantages for the level at which this book is pitched.

The chapter on the cardiovascular disorders has much useful information succinctly presented and has 422 references, all from well-known journals and textbooks. These references are mostly from literature published in the last 5 years; this makes the book extremely up-to-date. It is a pity however that none of the important statements in the text are specifically referenced. On a few occasions there is an irritating habit of referring to numbered tables which are not adjacent to the text and for which no page number is available. An excellent feature of the book is the quotation of the predictive power of investigations for some of the conditions discussed whenever these are available from the literature. Traditional units are used in the text for the most part but there are some inconsistencies and international units (S.I.) are occasionally used instead. Both units are tabulated for the routine range of biochemical variables in the Appendix but conversion coefficients are omitted. There is an obvious printing error about the units of sodium ions. The indexing is not extensive, in spite of the statement in the introduction; for example, the important section on resuscitation in the section on 'Medical Management of Trauma and Burns' is not listed at all!

The section on pulmonary embolus omits some valuable practical points in the diagnosis of this condition in the intensive care unit (ICU). The chapter on respiratory disorders for the most part covers the subject well and there are many useful tables and figures to convey essential understanding of normal and abnormal states with some original contributions from the author. The section on upper airway obstruction would be better if acute rather than chronic upper airway obstruction were considered. Cyanide poisoning in association with smoke inhalation is mentioned but there is no reference to its management. This chapter and that on cardiovascular disorders occupy over half the book. It is confusing to see dopamine as a cause of drug-induced nephrotoxicity without any reference to dosage.

The chapter on neurological disorders in the head injury section fails to emphasise sufficiently the possibilities of other coexisting injuries except for a fractured spine. The dangers of hypotension in the aggravation of head injury and its importance in some other area of major trauma is overlooked. The section on brain stem death fails to emphasise the importance of establishing the preconditions before carrying out the actual tests. The chapter on infection is particularly useful and the one on miscellaneous items has sections on the very important topics of severity of disease scoring systems, and ethical issues in the ICU. It was pleasing to see the present status of corticosteroids in regard to head injuries, aspiration pneumonia, smoke inhalation, and septic shock clearly stated. In situations that require urgent resuscitation, cannulation of neck veins is eschewed and a cut down at the antecubital fossa is recommended; British practitioners will find this advice curious.

This cannot be considered a practical manual. Beginners in the field of ICU, if they are persuaded to buy this book, will require to complement their reading by one of the more practical textbooks on the market. The next edition should improve the structure of some of the shorter chapters, improve the indexing and offer a more practical approach to the subject.

S. JACOBS

Anaesthesia, 1990, Volume 45, pages 80–85

Anaesthetic literature

This section of *Anaesthetic literature* contains references taken from *Current Contents—Life Sciences* for September 1989. The Journals which may be consulted when *Anaesthetic literature* is compiled are those listed in *Current Contents—Life Sciences*, published by the Institute of Scientific Information, Philadelphia, Pennsylvania, USA.

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The collator of this section is Dr L. Kaufman, MD, FFARCS, 145 Harley Street, London W1N 2DE. Dr Kaufman is prepared to provide on request, and at a modest charge, a new additional service to our readers. References from January 1984 have been entered on data base. The data are held on Dbase II, cpm 86 and on Dbase III, MsDos and are available on disc, together with a program providing search facilities. Enquiries direct to Dr Kaufman at the above address please.

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Treatment and medication

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Central nervous system

Physiology

The effect of orthostatic hypotension on cerebral blood flow and middle cerebral artery velocity in autonomic failure, with observations on the action of ephedrine. Brooks DJ, Redmond S *et al. Journal of Neurology, Neurosurgery and Psychiatry* 1989; **52:** 962.

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Clinical features of the sleep apnoea/hypopnoea syndrome. Whyte KF, Allen MB *et al. Quarterly Journal of Medicine* 1989; **72:** 659.

Treatment and medication

The effect of nimodipine and dextran on axonal function and blood flow following experimental spinal cord injury. Fehlings MG, Tator CH, Linden RD. *Journal of Neurosurgery* 1989; **71:** 403.

Peripheral pharmacokinetics of apomorphine in humans. Gancher ST, Woodward WR *et al. Annals of Neurology* 1989; **26:** 232.

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Endocrine and metabolic

Physiology

On the pathophysiology of functional acute renal failure. Andreucci VE, Memoli B *et al.* In: Bonomini V *et al.*, eds. *Biotechnology in renal replacement therapy.* Basel: S. Karger, 1989: **70:** 99.

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Increased plasma atrial natriuretic factor and reduced plasma renin in patients with poorly controlled diabetes mellitus. Bell GM, Bernstein RK *et al. Clinical Science* 1989; **77:** 177.

Naloxone abolishes the inhibiting effect of somatostatin on the release of oxytocin evoked by insulin-induced hypoglycemia in humans. Chiodera P, Gnudi A *et al. Metabolism—Clinical and Experimental* 1989; **38:** 709.

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Insulin receptor kinase defects in noninsulin-resistant tissues and their role in the pathogenesis of NIDDM. Haring H, Obermaier-Husser B. *Diabetes/Metabolism Reviews* 1989; **5:** 431.

Effect of catecholamines and insulin on plasma volume and intravascular mass of albumin in man. Hilsted J, Christensen NJ, Larsen S. *Clinical Science* 1989; **77:** 149.

Vasopressin-mediated forearm vasodilation in normal humans—evidence for a vascular vasopressin V2 receptor. Hirsch AT, Dzau VJ *et al. Journal of Clinical Investigation* 1989; **84:** 418.

Diabetic neuropathy: abnormalities of Schwann cell and perineurial basal laminae. Implications for diabetic vasculopathy. King RHM, Llewelyn JG *et al. Neuropathology and Applied Neurobiology* 1989; **15:** 339.

Depletion of cutaneous nerves and neuropeptides in diabetes mellitus—an immunocytochemical study. Levy DM, Karanth SS *et al. Diabetologia* 1989; **32:** 427.

A novel approach to the diagnosis and assessment of symptomatic diabetic neuropathy. Masson EA, Hunt L *et al. Pain* 1989; **38:** 25.

Persistent tardive dyskinesia and neuroleptic effects on glucose tolerance. Mukherjee S, Roth SD *et al. Psychiatry Research* 1989; **29:** 17.

Impairment of glutathione metabolism in erythrocytes from patients with diabetes mellitus. Murakami K, Kondo T *et al. Metabolism—Clinical and Experimental* 1989; **38:** 753.

Hyponatremia and inappropriate secretion of vasopressin (antidiuretic hormone) in patients with hypopituitarism. Oelkers W. *New England Journal of Medicine* 1989; **321:** 492.

The impact of obesity on the pathogenesis of non-insulin-dependent diabetes mellitus: a review of current hypotheses. Pedersen O. *Diabetes/Metabolism Reviews* 1989; **5:** 495.

Kidney function in newly diagnosed type-2 (non-insulin-dependent) diabetic patients, before and during treatment. Schmitz A, Hansen HH, Christensen T. *Diabetologia* 1989; **32:** 434.

Receptors for atrial natriuretic peptide (ANP) and regulation of thyroglobulin secretion by ANP in human thyroid cells. Sellitti DF, Tseng Y-CL, Wartofsky L. *Life Sciences* 1989; **45:** 793.

Insulin-antagonistic effects of counterregulatory hormones: clinical and mechanistic aspects. Smith U, Lager I. *Diabetes/Metabolism Reviews* 1989; **5:** 511.

Autoradiographic demonstration of oxytocin-binding sites in the macula densa. Stoeckel ME, Freund-Mercier MJ. *American Journal of Physiology* 1989; **257:** F310.

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Effects of intravenous AVP on cardiac output, mesenteric hemodynamics and splanchnic nerve activity. Veelken R, Danckwart L *et al. American Journal of Physiology* 1989; **257** (No. 2 Part 2): H658.

The kidney is the major site of cortisone production in man. Whitworth JA, Stewart PM *et al. Clinical Endocrinology* 1989; **31:** 355.

Treatment and medication

The effect of treatment of non-insulin-dependent diabetes mellitus (NIDDM) on serum lipids and lipoproteins. Baynes C, Feher MD, Elkeles RS. *Quarterly Journal of Medicine* 1989; **72:** 579.

Insulin resistance: a scientific and clinical challenge. Beck-Nielsen H. *Diabetes/Metabolism Reviews* 1989; **5:** 529.

Intraoperative glucose infusion and blood lactate: endocrine and metabolic relationships during abdominal aortic surgery. Degoute C-S, Ray M-J *et al. Anesthesiology* 1989; **71:** 355.

Abnormal nerve conduction in impotent patients with diabetes mellitus. Deniels JS. *Diabetes Care* 1989; **12:** 449.

Clinical aspects of diabetic nephropathy—the prognosis improves. Friedman EA. In: Bonomini V *et al.*, eds. *Biotechnology in renal replacement therapy.* Basel: S. Karger 1989; **70:** 41.

Characteristics of non-insulin dependent diabetic patients with secondary failure to oral antidiabetic therapy. Groop L, Schalin C *et al. American Journal of Medicine* 1989; **87:** 183.

Transplantation in diabetic patients. NAJARIAN JS, SUTHERLAND DER. In: BONOMINI V *et al.*, eds. *Biotechnology in renal replacement therapy*. Basel: S. Karger 1989; **70:** 56.

Management of diabetic ketoacidosis. SANSON TH, LEVINE SN. *Drugs* 1989; **38:** 289.

A preliminary trial of the programmable implantable medication system for insulin delivery. SAUDEK CD, SELAM J-L *et al. New England Journal of Medicine* 1989; **321:** 574.

Drug therapy—the physiologic replacement of insulin: an elusive coal. ZINMAN B. *New England Journal of Medicine* 1989; **321:** 363.

Pain

Physiology

Recent advances in the pathophysiology of acute pain. WOOLF CJ. *British Journal of Anaesthesia* 1989; **63:** 139.

Treatment and medication

Naproxen sodium versus pentazocine in treating postoperative pain. KVARNES L. *Current Therapeutic Research* 1989; **46:** 259.

The control of acute postoperative pain. MITCHELL RWD, SMITH G. *British Journal of Anaesthesia* 1989; **63:** 147.

Intraoperative cryoanalgesia for postthoracotomy pain relief. MULLER LCH, SALZER GM *et al. Annals of Thorac Surgery* 1989; **48:** 15.

A randomized, double-blind comparison of the effects of interpleural bupivacaine and saline on morphine requirements and pulmonary function after cholecyste VADEBONCOUER TR, RIEGLER FX *et al. Anesthesiology* 1989; **71:** 339.

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Obituaries

Blythe, Gaye Noelle, MB, BCh, FFARCS, formerly Anaesthetist, Cuckfield Hospital. Qualified from University of Wales 1975.

Dewar, Iain McCall Campbell, MB, ChB, FFARCS, formerly Consultant Anaesthetist of Victoria Infirmary, Glasgow. Qualified from University of Glasgow in 1927.

Edwards, George, MRCS, LRCP, FFARCS, DA, formerly senior Anaesthetist, St George's Hospital. Qualified from University of London in 1926.

Lee, Andrew Philip Bailiffe, MB, ChB, FFARCS, formerly Consultant Anaesthetist at West Suffolk Hospital, Bury St. Edmunds. Qualified from the University of Liverpool in 1971.

Mackintosh, F.G., MB, ChB, FCAnaes, DA, formerly Consultant Anaesthetist at Leeds General Infirmary. Qualified from Aberdeen University in 1937.

Murphy, T.T.P., OBE, TD, MD, FCAnaes, formerly Consultant Anaesthetist at Plymouth General Hospital. Qualified from University College Cork in 1919.

Northover, P.T., MD, FCAnaes, formerly Consultant Anaesthetist to Bath Clinical Area. Qualified from Edinburgh University in 1937.

Pearce, Edith Jane Legerton, MD, MB, BS, MRCS, LRCP, FFARCS, DA, formerly Anaesthetist of Harrogate General Hospital and Royal Bath Hospital. Qualified from University of London in 1930.

Roche, G.K.T., MB, BS, FCAnaes, DA, formerly Consultant Anaesthetist to Royal Dental and National Orthopaedic Hospitals. Qualified from University of London 1942.

Wallace, Patricia G., MRCS, LRCP, FCAnaes, DA, formerly Consultant Anaesthetist at Kettering General Hospital. Qualified from University of London 1944.

International congress calendar

1990

13–20 January. Virgin Islands. *8th Annual Symposium on Clinical Update in Anesthesiology.*
Information: Dr G. Silvay, Dept. of Anesthesiology, Box 1010, Mount Sinai School of Medicine, 1 Gustave L. Levy Place, New York, NY 10029-6574.

14–19 January. Hawaii. *Hawaiian Seminar on Clinical Anesthesia.*
Information: California Society of Anesthesiologists, 1065 East Hillsdale Boulevard, Suite 410, Foster City, California 94404, USA.

26–28 January. Los Angeles. *28th Clinical Conference in Pediatric Anaesthesiology.*
Information: Wayne Herbert, Program Director, Division of Anesthesia, Children's Hospital of Los Angeles, P.O. Box 54700, Los Angeles, California 90054, USA.

3–10 February. Colorado. *Aspen Anesthesia 1990.*
Information: Holiday Seminars, Route 1, Box 30, Goodlettsville, Tennessee 37072, USA.

3–10 February. Colorado. *Sixteenth Annual Vail Conference in Anesthesiology.*
Information: Sonja Craythorne, Professional Seminars, P.O. Box 012318, Miami, Florida 33101, USA.

10–17 February. Colorado. *Fifteenth Annual Vail Symposium in Intensive Care.*
Information: Sonja Craythorne, Professional Seminars, P.O. Box 012318, Miami, Florida 33101, USA.

24–26 February. New Orleans. *Mardi Gras Anaesthetic Course.*
Information: Professor A. Grogono, Tulane University Medical Centre, 1430 Tulane Avenue, New Orleans, Louisiana 70112, USA.

1–3 March. Mainz, Germany. *Second Postgraduate Course on Anaesthesia, Intensive Care Medicine, Emergency Medicine and Pain Treatment.*
Information: Prof. Dr W. Dick, Klinik für Anaesthesiologie, Langenbeckstr 1, D 6500 Mainz, FRG.

5–8 March. Ohio. *18th Obstetric Anesthesia Conference.*
Information: Arlene Rogers, The Ohio State University Hospitals, Department of Anesthesiology, 410 West 10th Avenue, Columbus, Ohio 43210, USA.

10–14 March. Honolulu. *64th Congress of the International Anaesthesia Research Society.*
Information: Professor E.A. Moffitt, IARS, 3645 Warrensville Center Road, Cleveland, Ohio 44122, USA.

17–23 March. Durban, South Africa. *National Anaesthetic Congress.*
Information: Professor D.A. Rocke, 1990 Anaesthetic Congress, Department of Anaesthetics, P.O. Box 17039, Congella 4013, South Africa.

19–22 March. Ohio. *10th Medical Monitoring Technology Conference.*
Information: Arlene Rogers, The Ohio State University Hospitals, Department of Anesthesiology, 410 West 10th Avenue, Columbus, Ohio 43210, USA.

26–29 March. Ohio. *17th Neonatal and Infant Respiratory Symposium.*
Information: Arlene Rogers, The Ohio State University Hospitals, Department of Anesthesiology, 410 West 10th Avenue, Columbus, Ohio 43210, USA.

27–30 March. Brussels, *10th International Symposium on Intensive Care and Emergency Medicine.*
Information: Dr J.L. Vincent, Dept. of Intensive Care, Erasme University Hospital, Route de Lennik 808, 1070 Brussels, Belgium.

2–6 April. Oxford. *Course in Clinical Neurophysiology.*
Information: Dr K.R. Mills, Clinical Neurophysiology Unit, University Department of Clinical Neurology, The Radcliffe Infirmary, Oxford, OX2 6HE.

4–6 April. Glasgow. *Junior Anaesthetists' Group of the Association of Anaesthetists of Great Britain and Ireland. Linkman Conference and Annual Scientific Meeting.*
Information: Honorary Secretary, Association of Anaesthetists

of Great Britain and Ireland, 9 Bedford Square, London, WC1B 3RA.

9–12 May. Vienna. *Third International Symposium on Echocardiography and Doppler in Cardiac Surgery.*
Information: G. Maurer, W. Mohl, c/o Interconvention, A–1450 Vienna, Austria.

13–16 May. Vienna. *5th Annual Meeting European Association of Cardiothoracic Anaesthesiologists.*
Information: Professor W. Haider, Department of Cardiothoracic Anaesthesia and Intensive Care, Spitalgasse 23, A–1090 Vienna, Austria.

13–19 May. Wellington, New Zealand. *Faculty of Anaesthetics and the Royal Australasian College of Surgeons Annual General Meeting.*
Information: Administrative Officer, Faculty of Anaesthetists, RACS, Spring Street, Melbourne, Victoria 3000, Australia.

17–20 May. San Francisco. *California Society of Anesthesiologists Annual Meeting.*
Information: California Society of Anesthesiologists, 1065 East Hillsadale Boulevard, suite 410, Foster City, California 94404, USA.

28 May–1 June. Montreal. *McGill University Annual Review Course in Anaesthesia.*
Information: Post Graduate Board, Royal Victoria Hospital, 687 Pine Avenue West, Room H308, Montreal, Quebec, H3A 1A1, Canada.

5–8 June. Amsterdam. *5th European Congress on Intensive Care Medicine 1990.*
Information: Secretariat, c/o Holland Organizing Centre, Lange Voorhout 16, 2514 EE, The Hague, The Netherlands.

15–19 June. Vancouver. *47th Annual Meeting of the Canadian Anaesthetists' Society.*
Information: Ms Ann Andrews, CAS 187, Gerrard St. E, Toronto, Ontario M5A 2E5 Canada.

5–8 September. Budapest, Hungary. *3rd International Symposium on Anesthesia for Cardiac Patients.*
Information: Dr G. Silvay, Department of Anesthesiology, Box 1010, Mount Sinai School of Medicine, 1 Gustave L. Levy Place, New York, NY 10029-6574, USA.

9–15 September. Warsaw. *VIIIth European Congress of Anaesthesiology.*
Information: The Organising Committee, VIIIth European Congress of Anaesthesiology, c/o The Polish Society of Anaesthesiology and Intensive Therapy, ul. Kasprzaka 17a, 01-211 Warsaw, Poland.

23–28 September. Seoul. *8th Asian/Australasian Congress of Anaesthesia.*
Information: Department of Anesthesiology, Seoul National University Hospital, 28 Yungun-Doug, Chongro-Ku, Seoul 110, S. Korea.

25–28 September. London. *Ultrasound Angiography.*
Information: The Conference Secretariat, P.O. Box 15, Eastleigh, Hampshire, SO5 5XG.

26–28 September. Manchester. *Linkman Conference and Annual Scientific Meeting.*
Information: The Honorary Secretary, Association of Anaesthetists of Great Britain and Ireland, 9 Bedford Square, London, WC1B 3RA.

19–23 October. Las Vegas. *American Society of Anesthesiologists Annual Meeting.*
Information: Executive Secretary, ASA, 515 Busse Highway, Park Ridge, IL 60068, USA.

3–4 November. New York. *28th Annual Bernard H. Eliasberg Memorial Symposium.*
Information: Anita Guffin, MMS, Mount Sinai Medical Center, One Gustave Levy Place, New York, New York 10029, USA.

5–10 November. Sao Paulo. *36th Brazilian Congress of Anesthesiology.*
Information: Dr R. Mathias, Rua Caiubi 666, Sao Paulo, Brazil 05010.

18–21 November. Kyoto, Japan. *4th International Symposium on the Pain Clinic.*
Information: 4th WSPC Secretariat, Department of Anesthesiology, Osaka Medical College, c/o Inter Group Corp., Shohaku Bldg., 6–23 Chayamachi Kita-ku, Osaka 530, Japan.

5–9 December. San Juan. *15th Caribbean Symposium in Anaesthesia and Related Fields.*
Information: Miguel Colon-Morales, GPO Box 4547, San Juan, Puerto Rico 00936.

8–12 December. New York. *Forty-fourth Postgraduate Assembly in Anesthesiology.*
Information: Kurt G. Becker, Executive Director, The New York State Society of Anesthesiologists Inc., 41 East 42nd Street, Suite 1605, New York 10017, USA.

1991

10–13 January. Miami. *28th Annual Post-Graduate Seminar in Anesthesiology.*
Information: Barbara McNulty, Continuing Education Programs, 7480 Fairway Drive, Suite 106, Miami Lakes, Florida 33014, USA.

2–9 February. Colorado. *17th Annual Vail Conference in Anesthesiology.*
Information: Sonja Craythorne, Professional Seminars, P.O. Box 012318, Miami, Florida 33101, USA.

8–12 March. San Antonio. *65th Congress of the International Anesthesia Research Society.*
Information: Emerson A. Moffitt, IARS, 3645 Warrensville Center Road, Cleveland, Ohio 44122, USA.

3–5 April. Oxford. *Junior Anaesthetist's Group of the Association of Anaesthetists of Great Britain and Ireland Linkman Conference and Annual Scientific Meeting.*
Information: Association of Anaesthetists of Great Britain and Ireland. 9 Bedford Square, London, WC1B 3RA.

15–18 April. Hamamatsu, Japan. *6th International Symposium on Computing in Anesthesia and Intensive Care.*
Information: Dr K. Ikeda, Chairman of the Organizing Committee, c/o Department of Anesthesiology, Hamamatsu University School of Medicine, 3600 Handa-cho, Hamamatsu, Shizuoka, 431–31 Japan.

1–4 May. Montreal. *2nd International Symposium on Pediatric Pain.*
Information: Pain Secretariat, 3450 University Street, Montreal, Quebec H3A 2A7, Canada.

3–5 May. Philadelphia. *AUA Annual Meeting.*
Information: Stephen J. Prevoznik, Department of Anesthesia, Hospital of the University of Pennsylvania, 3400 Spruce Street, Philadelphia, Pennsylvania 19104, USA.

9–12 May. Washington DC. *6th International Dental Congress on Modern Pain Control.*
Information: American Dental Society of Anesthesiology, Inc., 211 E. Chicago Avenue, Suite 948, Chicago, IL 60611.

27–31 May. Montreal. *McGil University Annual Review Course in Anaesthesia.*
Information: Post Graduate Board, Royal Victoria Hospital, 687 Pine Avenue West, Room H308, Montreal Quebec, H3A 1A1, Canada.

21–25 June. Quebec City. *48th Annual Meeting of Canadian Anaesthetists' Society.*
Information: Ms Ann Andrews, CAS, 187 Gerrard St. E., Toronto, Ontario M5A 2E5, Canada.

11–13 September. Harrogate. *Linkman and Annual Scientific Meeting of Association of Anaesthetists of Great Britain and Ireland.*
Information: Association of Anaesthetists of Great Britain and Ireland, 9 Bedford Square, London, WC1B 3RA.

26–30 October. San Francisco. *American Society of Anesthesiologists Annual Meeting.*
Information: Executive Secretary, ASA, 515 Busse Highway, Park Ridge, IL 60068, USA.

7–11 December. New York. *Forty-fifth Postgraduate Assembly in Anesthesiology.*
Information: Kurt G. Becker, Executive Director, The New York State Society of Anesthesiologists Inc., 41 East 42nd Street, Suite 1605, New York 10017, USA.

1992

1–8 February. Colorado. *18th Annual Vail Conference in Anaesthesiology.*
Information: Sonja Craythorne, Professional Seminars, P.O. Box 012318, Miami, Florida 33101, USA.

13–17 March. San Francisco. *66th Congress of the International Anesthesia Research Society.*
Information: International Anesthesia Research Society, 3645 Warrenville Center Road, Cleveland, Ohio 44122, USA.

29 March–2 April. Atlanta, Georgia. *The Third International Symposium on the History of Anaesthesia.*
Information: R.K. Calverley, Medical Center, University of California, 225 Dickinson Street, San Diego, California CA 92103, USA.

12–19 June. The Hague. *10th World Congress of Anaesthesiology.*
Information: Dr Harm Lip, Nilantsweg, 99, 8041 AR Zwolle, Netherlands.

17–21 October. New Orleans. *American Society of Anesthesiologists Annual Meeting.*
Information: Executive Secretary, ASA, 515 Busse Highway, Park Ridge, IL 60068, USA.

12–16 December. New York. *46th Postgraduate Assembly in Anesthesiology.*
Information: Kurt G. Becker, Executive Director, The New York State Society of Anesthesiologists, Inc., 41 East 42nd Street, Suite 1605, New York 10017, USA.

1993

12–16 February. Utah. *38th Annual Postgraduate Course in Anesthesiology — 'Anesthesiology: Today and Tomorrow'.*
Information: Vicky Larson, Department of Anesthesiology, University of Utah School of Medicine, 50 North Medical Drive, Salt Lake City, Utah 84132, USA.

29 April–2 March. North Carolina. *Meeting of the Association of University Anesthetists.*
Information: Francis M. James III, Department of Anesthesia, Wake Forest University Medical Center, 300 S. Hawthorne Road, Winston-Salem, North Carolina 27103, USA.

15–17 September. Glasgow. *Joint Meeting between the Association of Anaesthetists of Great Britain and Ireland and the Canadian Society of Anaesthetists.*
Information: The Honorary Secretary, Association of Anaesthetists of Great Britain and Ireland, 9 Bedford Square, London, WC1B 3RA.

9–13 October. Washington DC. *American Society of Anesthesiologists Annual Meeting.*
Information: Executive Secretary, ASA 515 Busse Highway, Park Ridge, IL 60068, USA.

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Index of computer programs

010.01.12

Author C. Brown
4 Gloucester Drive, Sale, Cheshire, M33 5DH

Title Psion program suite

Description OPREC, a personal anaesthesia records database. REFS, reference database. PAED, paediatric calculator, derives tube sizes, blood volumes, fresh gas flow rates and drug doses. DOSE, infusion rate calculator, derives rate in ml per minute or hour, or dose in mg or μg per kg per minute. All these fit on one 'Datapak', a miniature memory device for the Psion; a second datapak can record entered data.

Language OPL. (Basic like language for the Psion Organiser.)

Computing facility Psion Organiser XPII.

Availability On 16K Datapaks, or as listings, from the author.

004.01.12

Authors J. M. Watt, M. Brewin
The Queen Elizabeth Hospital, Edgbaston, Birmingham, B15 2TH.

Title CARKAS (Computerised anaesthesia record keeping and audit system.)

Description This system combines theatre record keeping with a departmental audit system. Using a cheap pocket computer (Price c. £100), the anaesthesia record is entered in theatre by mainly single key entry through a hierarchical menu structure. Entries may be reviewed and edited, at the time, before downloading directly into a PC database for audit. The same 'Comms Link', a plug-in serial interface, connects the Psion to either a printer in the theatre, to print out a hard copy of the record for entry in the patient's notes, or to transfer the files from the Psion to a PC. Once the data is in the PC, a database language procedure incorporates it into the main database file. The system consists of two parts; a 'front page' of the pre-op details, drugs and doses, gases, anaesthetic systems, monitors and intravenous access and a 'back page' of chart details, vital signs, drug increments, fluids and event comments, each entry timed by the Psion's internal clock.

Language OPL. (Basic-like language for the Psion Organiser.)

Computing facility Psion Organiser II; Psion Communications Link; IBM-PC compatible computer; Printer (Serial interface).

Database Psion PC 'Archive'. (Runs under MS-DOS)

Availability 16K Datapaks, from the authors.

033.01.24

Author R. Marks, 73 Calabria Road, London N5.

Title Drug Infusion Spreadsheet.

Description A spreadsheet template macro for calculating infusion rates for drugs. The spreadsheet is fully menu driven and is straightforward to use. Users are prompted for the drug name and patient's weight. The recommended dilution for the drug name is taken from a built-in reference table, and a listing is then given relating the dosage in μg/kg/minute to the flow rate in ml/hour. The drug dilution can be altered when necessary on each patient, and the facility also exists to amend or add drugs to the reference table. A paper printout of up to four drug-infusions is produced. The system has been routinely used in a cardiothoracic ICU for a year, and has achieved popularity with both nursing and medical staff.

Language Lotus 1–2–3, or Borland Quattro. (Under MS-DOS).

Computing facility IBM-PC compatible computer. Printer.

Availability 5.25 inch discs, from the author.

034.01.22

Author J. E. Hammond, East Surrey Hospital, Three Arches Road, Redhill, Surrey RH1 5RH.

Title APACHE II Score.

Description The program allows a user, with minimal knowledge of computers, to enter APACHE II physiological parameters, and then calculates and displays the APACHE II score. The score and the parameters are stored onto disc, and a printout of the current or previous scores may be obtained at any time.

Language dBase III (Under MS-DOS).

Computing facility IBM-PC compatible. (Implemented on Amstrad PC.)

Availability 5.25 inch discs, from the author.

035.01.24

Author G. L. Hutchinson, Department of Anaesthesia, Ninewells Hospital, Dundee DD1 9SY.

Title ICU Aid (A multi-purpose ICU calculator).

Dr J.R. Davies (*Department of Anaesthesia, Royal Lancaster Infirmary, LA1 4RP*) has assumed responsibility for the preparation of this item. Please send details of your programs to him. They should be relevant to anaesthesia, intensive care, basic sciences or teaching.

Description ICU Aid performs a variety of calculations of use in the Intensive Care Unit, including: energy requirements, calculated from age, sex, height and weight, with details of sepsis, trauma, mobility, etc; nitrogen balance, from urea and protein losses; cardiovascular and respiratory indices, from pulmonary artery pressures and cardiac output measurements; derive vascular resistance, indices of stroke work, myocardial oxygen demand, shunt, A-a gradient and oxygen transport/delivery. Normal values are also displayed. Other calculations available include infusion rates, APACHE II scores and routines for body surface area, creatinine clearance, burns fluid replacement and transfusion volumes. SI and imperial units are accepted, but either may be made mandatory. The program includes an explanatory introduction, a complete set of references to the sources used and continuous on-screen advice.

Language MicroSoft Quick Basic 4.56 (Under MS-DOS 2.1 or higher). The Basic program is compiled, and runs under MS-DOS.

Computing facility IBM-PC compatible.

Availability 5.25 inch or 3.5 inch discs, from the author.

036.01.24

Author J. G. Allen, 7, Westfield Drive, West Winch, King's Lynn, Norfolk PE33 0PF.

Title FLO.

Description. A program for translating 'dose' to 'flow' for any drug given by infusion. Many commonly infused drugs can be selected from a built-in menu. Other drugs may be entered manually. Calculations can be performed either for a specific patient, or for a range of patient weights. Printouts of charts in both formats may be produced.

Language Turbo Pascal.

Computing facility IBM-PC compatible.

Availability 5.25 inch DD DS disc, from the author. (Please send a formatted disc, and an A4 SAE for the manuals.)

037.01.14

Authors A. P. Baranowski, P. M. Murphy, D. Garvie, M. N. E Harris, J. A. Mathias, Departments of Anaesthetics and Paediatrics, St. Thomas' Hospital, Lambeth Palace Road, London SE1.

Title PAEDS (Paediatric Anaesthesia Worksheet).

Description Many departments and anaesthetists use standard lists of physiological constants, drug dosages and infusion regimens. To improve safety in paediatric anaesthesia, this program calculates and provides a printout of these parameters for the individual patient. The structure of the program (an automatic macro) allows detailed calculations to be made, using subsets of the standard calculations, depending on variations in the patient's weight and height. In particular, a completely separate set of calculations is used for children under one year old. The printout includes normal physiology, anaesthetic drugs and sizes, antibiotics and resuscitation drugs and infusions and is a convenient size to be inserted in the notes of the patient's current admission.

Language Lotus 1-2-3 (Under MS-DOS).

Computing facility IBM-PC compatible.

Availability From the authors.

Index of Computer programs list

Code no.	Title	Reference
019.01.12	GasCard	85;40;97
004.01.25	Alfabit	85;40;518
020.01.14	Paeds I & II	85;40;518
004.02.11	Visual Perception Test	85;40;518
005.01.13	Interactive Rota-Scheduler	83;38;824
011.01.12	ANREC (ANaesthetic RECords)	84:39:509
010.01.21	CVSPROG	85:40:1028
031.01.12	P. of Wales Anaes. Rec. System	
004.02.32	MCQ	86:41:789
020.02.13	Shortlist	86:41:1171
029.01.24	Upp. v. Low. Airway Stenosis	87:42:449
032.01.32	CALREAD (For AM STRAD CPLs)	88:43:528
030.02.31	Emergency First Aid (Save-a-Life)	88:43:528
032.02.32	IV DRUGS (Pharmacokinetics)	88:43:528
013.01.31	LoFlow	84:39:509
013.03.22	1CU REC	84:39:509

Survey of Index

A questionnaire was sent last year to the authors of the first 50 programs which were on the Index, to discover if they had found the Index useful in the dissemination or improvement of their programs, and if they were still relevant. Twenty-six replies were received, and the answers are summarised in Table 1.

Table 1

Program in regular use	10 (on 15 sites)
Enquiries received	112
Did you find such contacts helpful?	5
Program updated since entry?	9
Program updated?	2
Retain program in Index?	16

Few programs had survived to be used regularly, and six of those sites used one of two programs. The more popular the program, the more enquiries received and the more helpful the authors found them. It remains to be discovered if the enquirers found the Index similarly helpful.

The response rate was good for this type of postal questionnaire, but half of those responding did not wish to retain their program in the Index. Presumably, those not responding would feel the same, and a list of 'current' Index programs heads this section.

This apparent erosion parallels the rapid turnover of software in other fields, and few programs achieve an established position. If it is considered as 'evolution in action' then the questionnaire has shown the Index to be performing a useful task.

Note

A number of common factors often detract from the generally high standard of programs submitted to the Index. If authors would attend to these points it would considerably improve the acceptability and value of their work.

Testing. Authors cannot test their own programs. An initial test should be by a colleague who tries out the program, followed by a larger number of people, preferably in the absence of the author and in a real-life setting. This will reveal many quirks and errors which authors would not consider a problem, or would never encounter.

Validation. Most programs require the user to enter data. Such entries should be checked by the program *and* by the user who should have the opportunity to confirm the data after entry and before it is used by the program.

Disclaimer. If a program is designed to guide treatment of patients then it should, for the protection of the author, warn users to be guided always by their own clinical judgement. Product liability extends to software.

Presentation. Authors should remember that what is familiar and clear to them may be unfamiliar and confusing to the user. A well-thought-out presentation of the data entry and display parts of the program will help the user. The presentation of commercial programs is a useful guide, but common faults include scrolling screens, unhelpful error statements and inconsistent methods of data entry.

Work in progress. Authors who wish to inform others of substantive projects in preparation may be able to do so through the Index.

Submissions and enquiries should be sent to Dr J. R. Davies (Department of Anaesthesia, Royal Lancaster Infirmary, Lancaster LA1 4RP) in the form of a description of the program, as above, and a copy of the program, on floppy disc(s). They should be relevant to anaesthesia, intensive care, basic sciences or teaching.

J. R. Davies

Anaesthesia, 1990, Volume 45, pages 92–100

Association of Anaesthetists of Great Britain and Ireland

Annual Report of Council 1988–1989

1. Membership of the Association (as at 30.7.89)

The total Membership of the Association 5617 (5483)

Honorary	34	
Ordinary	2073	(2093)
Junior	2064	(1961)
Corresponding	33	(32)
Overseas	903	(909)
Retired	488	(432)
Senior	10	(11)
Associate	12	(12)

(Last year's figures in brackets).

There were 69 resignations during the year.

Deaths

Council records with regret the death of the following members:

Binning, R. (*Hove*), Blythe, G.N. (*Cuckfield*), Brown, I.M. (*Stockport*), Church, C.G. (*Keighley*), Dinsdale, T. (*Orkney*), Edwards, G. (*London*), Foulds, S.B. (*Cheadle*), Gibson, J.B. (*Morpeth*), Hewer, A.J.H. (*Burford*), Lee, A.P.B. (*Bury St. Edmunds*), Lee, J.A. (*Westcliff on Sea*), Sir Geoffrey Organe (*Calne, Wiltshire*), Sampaio, M. (*Belfast*), Smiedt, N.C. (*South Africa*), Sobhy, M.R. (*Wigan*), Thornton, H.L. (*London*).

2. Honorary Membership

Council recommended for election to Honorary Membership:

Dr M.P. Coplans, Dr M.W. Johnstone, Dr C. Parsloe, Professor J.P. Payne.

3. Pask Certificate of Honour

Council made the award of Pask Certificates of Honour to:

Dr P. Butler, Registrar in Anaesthesia, Leicester; Dr E. Egan, Consultant Anaesthetist, Tanzania; Dr M.J. Mowbray, Senior Registrar in Anaesthesia, Nottingham; Dr D.S. Savage, Medicinal Chemist, Glasgow, (deceased 28.8.88).

4. Annual Scientific Meeting 1988

The Annual Scientific Meeting was held at the Boldrewood Conference Centre, University of Southampton on Thursday and Friday 15–16 September 1988. An excellent scientific and social programme had been organised by Dr D.A. Saunders, Dr J.C. Edwards, Professor J. Norman and their colleagues in Southampton. There were over 520 registrants. The John Snow Lecture, 'Science and Medicine', was delivered by the Right Honourable Dr David Owen, MP.

The Annual Dinner was held at the Brabazon Suite, Beaulieu. Professor D.J.P. Barker, PhD, FRCP, FFCM, Director of MRC Environmental Epidemiology Unit, gave the toast, 'The Association'. Other distinguished guests included Councillor Mrs M.P. Bear, Mayor of Southampton, Professor C.F. George, Dean, The Medical School, University of Southampton, Professor I. Taylor, MD, ChM, FRCS, Professor J. Shearer, PhD, FRCS, Professor J.D. Pickard, Mr J. Sealey and Councillor D. Maddock.

5. Annual General Meeting 1988

The Annual General Meeting was held at the Boldrewood Conference Centre, University of Southampton, on Friday 16 September, 1988. The President, Professor M. Rosen, was in the chair and over 200 members were present.

Honorary Membership was conferred on Professor J.W. Dundee (introduced by Dr G.W. Black), Dr Aileen K. Adams, CBE and Lord Smith of Marlow, KBE.

Dr Adams and Lord Smith were unable to be present at Southampton, the presentation being on Friday 13 January 1989 at the Winter Scientific Meeting.

Pask Certificates of Honour were awarded to M. Freeman, Esq. Chairman, British Anaesthetic and Respiratory Equipment Manufacturers Association, and Dr J.E. Fairfield, FFARCS (*London*).

The Minutes of the meeting have been circulated to members.

6. Linkman Conference 1988

The thirteenth Annual Conference of Linkmen was held at the Boldrewood Conference Centre, University of Southampton, on Wednesday 14 September, 1988. The President, Professor M. Rosen, was in the Chair and 207 Linkmen attended. The topics discussed were efficiency in the operating theatre, assistance for the anaesthetist, duties of the divisional chairman, standards of monitoring during anaesthesia and recovery, adverse drug reactions — new reporting system, intensive care services, the 'safety net', AIDS and the anaesthetist, medical defence associations' subscriptions and stress in trainee anaesthetists.

A detailed report of the conference has been circulated to Linkmen and published in the August 1989 issue of *Anaesthesia.*

7. Postgraduate Study Day 1988

This meeting, held jointly with the Faculty of Anaesthetists at the Royal College of Surgeons of England, London, on Saturday 15 October 1988, was again successful. The format of previous years was maintained, thereby enabling registrants to attend six lectures of their choice from the total of 18 lectures delivered. There were 259 registrants, which was fewer than in previous years.

8. Winter Scientific Meeting

Once again the Winter Scientific Meeting of the Association, held on Friday and Saturday 13–14 January 1989 at the Royal College of Surgeons of England, London, was an outstanding success. Some 379 registrants attended the excellent scientific programme compiled by Dr W.S. Nimmo.

Certificates of Honorary Membership of the Association were presented to Dr Aileen K. Adams, CBE (introduced by Dr P.W. Thompson, MBE) and Lord Smith of Marlow, KBE (introduced by Professor Sir Gordon Robson, CBE).

A lecture, supported by Radiometer Ltd. and entitled 'History and current status of oximetry', was delivered by Professor J.W. Severinghaus, (*San Francisco*).

The Winter Dinner was held at the Waldorf Hotel, Aldwych, London on Friday 13 January 1989. The Right Honourable Mrs Lynda Chalker, Minister of State for Foreign Affairs, gave the Toast, 'The Association'. Other distinguished guests included Lord Smith of Marlow, Sir David Innes Williams, Sir Christopher Booth, Sir Cecil Clothier, Professor Sir Gordon Robson, Professor M. Rosen, Mr G. Pinker and Professor G.D. Chisholm.

9. Annual Scientific Meeting for Junior Anaesthetists 1989

This meeting, hosted by the Department of Anaesthesia, Stoke-on-Trent, was held at the Chancellor's Building, University of Keele, on 5–7 April 1989. This very successful meeting was organised by Dr N.W.B. Clowes, Dr A.A. Tomlinson, Dr B.A.C. Smith, Dr D. Howes and Dr A. Mackenzie. Some 210 anaesthetists in training attended.

The scientific programme included sessions devoted to resuscitation and anaesthesia in difficult circumstances, spinal deformities in children, anaesthesia for transplantation, monitoring in the '90s, ethics of anaesthetic research and respiratory and anaesthetic aspects of obesity.

The Pinkerton lecture, entitled 'Clinical and resource management. What are the options for anaesthetists?', was delivered by Professor R. Dyson, Department of Adult Education, University of Keele.

The prize and President's medal for the Junior Anaesthetists Annual Prize Competition was awarded to Dr A.J. Martin, Senior Registrar (*Manchester*) for his paper entitled, 'A randomised double blind study to assess the effect of pH adjustment on discomfort caused by intradermal injection of lignocaine'. A second prize was awarded to Dr J.R.M. Read, Bangour General Hospital, (*West Lothian*).

10. Other Meetings

(i) Joint Meeting of the Canadian Anaesthetists' Society and the Association of Anaesthetists of Great Britain and Ireland, Ottawa Congress Centre, Ottawa, 9–13 June 1989.

Some 75 members of the Association and accompanying persons attended this meeting which attracted approximately 700 delegates in all.

The scientific programme included refresher course lectures, symposia, seminars, workshops, free paper and poster sessions in which a number of eminent UK anaesthetists participated by invitation. The Canadian Anaesthetists' Society, Royal College Annual Lecture, 'Evolution and toxicity of oxygen', was delivered by Dr J.F. Nunn, Director, Division of Anaesthesia, Clinical Research Centre, Harrow, Middlesex. An enjoyable social programme was concluded with the President's Reception and Annual Dinner Dance at the Westin Hotel. On behalf of Council of the Association of Anaesthetists, Dr M.M. Burrows, President, presented Pask Certificates of Honour to Dr P. Duncan, President, and Dr J. Cowan, Chairman of Council, Canadian Anaesthetists' Society. Dr Burrows then accepted a magnificent carving of a common loon (great northern diver), a gift from our Canadian colleagues, in commemoration of this inaugural meeting.

(ii) European Academy of Anaesthesiology

The first open meeting of the European Academy of Anaesthesiology, organised by the Association of Anaesthetists, was held at the Royal College of Surgeons of England, 13–15 July 1989, and included a refresher course of 14 lectures, which were repeated the following day, a free paper session, a scientific prize competition and guest lectures. There were 118 participants. The scientific prize, £1000, presented by the European Section, WFSA, was awarded to Dr C.S. Goodchild, Leeds, England, for his presentation entitled, 'The mechanisms by which benzodiazepines produce spinally-mediated analgesia'.

Next year this meeting will be held at Mainz, FRG 1–3 March and will be organised by the German Society of Anaesthesia and Intensive Care Medicine.

11. Council

In the year October 1988–September 1989 Council met on five occasions and the Advisory Committee also met on five occasions. The attendance of members of Council and the Advisory Committee is detailed in Appendix A, together with the membership of subcommittees and working parties.

Council is immensely appreciative of the services of the Association's secretarial staff, Miss Ann Muir, Administrative Secretary and her assistant, Mrs Betty Tyler, Miss Pat Plant, Financial Secretary, assisted by Miss Lyn Hunt, Mrs Lesley Ogg, BOC Educational Coordinator, Mrs Mary Richards, Minute Secretary, and Dr Audrey Eccles, ICI Archivist/Librarian. Council again wishes to record sincere gratitude to Mr E. Warburton, Honorary Financial Adviser, for his continuing, outstanding support and advice to the Association on legal and financial affairs.

Dr P. Morris, will relinquish office having served a total of 4 years as Assistant Honorary Secretary, Honorary Secretary and Immediate Past Honorary Secretary respectively. Council is deeply indebted to Dr Morris for his continuous total commitment to the immense workload of the secretarial duties during a period of remarkable extension of the Association's activities. Dr R.S. Atkinson will retire from Council having completed 2 years as Vice-President; his wise counsel on a wide range of important matters has been invaluable. Council gratefully acknowledges the contribution of Dr M.T. Inman, who retires from Council following many years of distinguished service as member of Council, Honorary Secretary, Vice-President, and Chairman of the Private Practice and International Relations Committees. Dr K. Budd and Dr W.S. Nimmo will retire from Council after 4 years in office as elected members. Their contributions to the work of the Association are gratefully acknowledged. That of Dr Nimmo who served as Chairman of the Education and Research Committee for the past 2 years is particularly noteworthy.

In October 1988 Council noted with great satisfaction the founding of the College of Anaesthetists and warmly congratulated Professor M. Rosen, Immediate Past President of the Association of Anaesthetists and Dean of the Faculty of Anaesthetists, RCS of England on becoming the first President of the new College. Council of the Association of Anaesthetists and Council of the College of Anaesthetists have agreed to co-sponsor a new senior lecturer post in intensive care for 5 years. Applications from university and other interested departments of anaesthesia to host this post were considered. From a shortlist of three departments visited by a small subcommittee, the University Department of Anaesthesia at Birmingham has been selected. The post will now be advertised. The annual cost, £60 000, will be shared equally between the Association and the College.

A report of the Association's Survey of Anaesthetic Practice, prepared by Dr J.N. Lunn and Dr W.L.M. Baird, Coordinators, was submitted to Council. A summary of the report was presented at the Winter Scientific Meeting. Copies of the report were sent to Linkmen to be made available to all members and to the divisional chairman of each hospital which participated in the survey.

Council of the College of Anaesthetists has accepted Council's invitation to form a Joint Working Party to consider the workload of consultant anaesthetists and to update the Association's recommendations, last published in 1983. The Working Party has already met twice and it is anticipated that a draft report will be presented to both Councils in the autumn.

12. Association Standing Committee, Republic of Ireland

The Standing Committee met at the Royal College of Surgeons in Ireland, in November 1988 and in May 1989; these meetings were attended by Dr M.M. Burrows, President, Dr W.R. MacRae, Honorary Treasurer, and Dr W.L.M. Baird, Honorary Secretary.

A comprehensive document, 'Anaesthesia in Ireland—the provision of a safe service', prepared by the Standing Committee, has now been published, submitted to the Ministry of Health and all health boards throughout the Republic and distributed to all consultant anaesthetists practising in the Republic.

Discussions took place between representatives of the Standing Committee and the Voluntary Health Insurance Board on professional fees for anaesthetics continue.

13. Linkman Organisation

During the current year a document setting out the duties of Linkmen has been circulated together with three Linkman Newsletters compiled by Dr J.E. Charlton, Assistant Honorary Treasurer, acting in his new capacity of Linkman Coordinator. Dr Charlton, in his inimitable style, has sought to inform members of the important initiatives being undertaken by Council. He has emphasised the need to establish and maintain links between members of the Association and Council. At all times the information and opinions received from Linkmen are valued highly by Council and Officers.

The current list of Linkmen is given in Appendix B.

14. Seminars and Workshops at 9 Bedford Square

The programme of seminars and workshops has continued to expand and throughout the year seminars on a wide range of topics have been held. Many seminars are now oversubscribed and a 'waiting list' system has had to be instituted; members are advised to make early application.

Council has agreed that there should be a modest increase in the registration fees to offset increasing overhead costs.

Council is deeply grateful to Dr J.A.W. Wildsmith, Seminar Coordinator, and the members of the seminar organising committee, Dr W.S. Nimmo and Dr J.F. Nunn. The administration skills of Mrs Lesley Ogg, BOC Educational Coordinator, are also gratefully acknowledged.

15. Education and Research Committee

Three meetings of the Education and Research Committee (Chairman Dr W.S. Nimmo) were held during the year.

Scientific meetings

The Committee reviewed draft programmes for the Winter and the Annual Scientific Meetings for 1989 and 1990 as well as the JAG Annual Scientific Meetings and recommended their approval to Council.

Postgraduate Study Day

Dr W.S. Nimmo and Dr J.A.W. Wildsmith represent the committee on the working party to prepare the programme for the postgraduate study day to be held on Saturday 21 October 1989.

JAG Questionnaire for Registrars

The final draft was approved and circulated.

Adverse Drug Reactions

Progress was reviewed on the one-year pilot scheme of reporting adverse drug reactions associated with anaesthesia on a new yellow form. The overall response has been disappointing but the committee has recommended to Council that the scheme should be continued for a further year.

Association Research Fellowship 1988–90

The Committee recommended to Council that this should be awarded to Dr Patrick Armstrong (*Edinburgh*) in support of his project, 'Nitrous oxide and urinary formiminoglutamic acid', under the direction of Professor A.A. Spence.

Research Grants

Council approved the following research awards recommended by the committee. Dr J. Kinsella (*Glasgow*), £4805 to study pulmonary alveolar macrophage function in fire victims. Dr F. Carli (*Northwick Park*) £3251 to study the effect of extradural blockade and active warming on protein metabolism in patients undergoing colonic surgery. Six other requests were reviewed but not recommended for support.

There was concern about the quality of some applications and guidelines were reviewed and expanded. The new draft guidelines have been considered by the Committee and are to be submitted to Council.

Travel Grants

Four applications for travel grants were recommended to Council for approval: Dr P.A. Farling (*Belfast*) £500 to visit neurosurgical centres in the USA. Dr C.R. Monk (*Bristol*) £500 to visit the Cardiac Surgical Unit, Boston Children's Hospital, USA. Dr J.P. Nolan (*Bristol*) £500 to visit trauma centres in the USA. Dr M.A. Garrioch (*Glasgow*) £500 to visit trauma centres in the USA.

Other grants

Additional awards for educational visits to third world countries were approved by Council: Dr Julie A. Freeman (*Edinburgh*) £1000 to take up a one-year post in the Children's Hospital, Kathmandu. Dr M.T. Inman (*Plymouth*) £1179 to attend the WFSA Refresher Course, Tanzania, September 1989, as the Association of Anaesthetists Visiting Lecturer.

Baxter Travelling Fellowship

In 1988 this was awarded to Dr P. Millns (*Birmingham*) to study fluid balance in pre-eclampsia.

The terms of reference of this grant now include trauma/resuscitation.

Undergraduate Essay Prize

Four submissions were considered for the 1989 prize and the following awards were recommended: 1st prize to J.A. Snowden (*University of Leeds*) for 'The relationships between clinical presentation, *in vitro* contracture studies and quantitative muscle histology in patients with malignant hyperpyrexia'. The 2nd prize went to J. Millo (*Royal Free Hospital, London*) for 'The relief of postoperative pain'.

The Association is grateful to all the experts who assisted with reviewing applications during the year.

16. Safety Committee

The Committee (Chairman, Professor A.P. Adams) continues to address the problem of inadvertent administration of carbon dioxide. Council has already advised that CO_2 cylinders shall always be removed from the anaesthetic machine except when the anaesthetist specifically intends to use this gas for a particular patient. Members are reminded that empty yokes should routinely be fitted with blanking plugs to prevent back-flow should the check-valves be faulty, and the importance of proper servicing is emphasised. The Committee is also working closely with the British Anaesthetic and Respiratory Equipment Manufacturers Association to promote a modified CO_2 flowmeter restricting flow rate to 500 ml per minute $\pm 20\%$; at this flow rate the bobbin should be half way up the flowmeter tube. Publicity on these matters is directed to members through *Anaesthesia News*.

The Committee receives enquiries from members seeking advice or guidance on a variety of matters, e.g. obsolescence and maintenance of equipment; hazardous chemicals, equipment or practices; withdrawal of drugs by manufacturers.

Draft documents on standards relating to anaesthetic and respiratory systems equipment are commented upon by the Committee.

It may be a surprise to members to learn that International Standards for Colour of Cylinders and Pipelines containing Medical Gases are not applied in many countries, including some in the EEC.

Disconnexion of breathing system components is common. Members are reminded of the recommendations contained in Health Equipment Information No. 150 (Dec. 1985) that conical fittings must be 'twisted' or 'wrung' together to ensure a firm contact between the mating surfaces ('push and twist'). In the long-term it is envisaged that lockable connectors will be introduced and this subject is now under discussion in the ISO.

Product liability was introduced on 1 March 1988 under the Consumer Protection Act (1987) and a medicolegal article appeared in the *British Medical Journal* 1988; **296:** 635. Full records identifying the source of, for example, items of equipment need to be kept for 10 years; after 10 years have elapsed, the anaesthetist, not the manufacturer, will be held legally responsible should a claim arise from the use of defective equipment.

The potential dangers of a removable plug situated at the lower end of some reservior bags (e.g. in paediatrics) has been considered and taken to the BSI Committee HCC45.

The Safety Committee considers it is essential to obtain prior informed consent for intravenous sedation, whatever the procedure to be performed.

Members are advised that the booklet 'Theatre Safeguards' published by the Medical Defence Societies and the Royal College of Nursing in collaboration with the National Association of Theatre Nurses has now been revised (1988).

On the problems regarding labelling of ampoules, vials and user-applied labels to syringes, the Committee has been ably assisted by the Principal Pharmacist at the National Centre of Responsibility for Pharmaceuticals aided by an expert on design typography in its efforts to improve legibility. It is also in close liaison with other individuals and organisations overseas working on similar lines.

The subject of awareness during anaesthesia continues to be of major concern and to attract attention from the media. Judgemental factors rather than equipment failures are mostly responsible. However, unnoticed accidental operation of the oxygen flush control has been responsible for awareness during general anaesthesia on a number of occasions. The Committee is exploring with BAREMA the possibility of incorporating a simple whistle into the oxygen bypass to alert the anaesthetist to its operation.

17. International Relations Committee

This Committee (Chairman, Dr M.T. Inman) has met on three occasions during the year. Further requests for help have been received from Nepal, Zambia, Ghana and Fiji. A consultant and a registrar were recruited by the Overseas Development Administration for a year in Fiji, and a post FFA registrar is now working at the Children's Hospital in Kathmandu. Efforts are continuing to fill posts in Ghana and Nigeria.

The Committee continues to liaise with the British Council, Overseas Development Administration, the World Federation of Societies of Anaesthesiologists, and the 'World Anaesthesia' Group.

Members of the Committee have been involved in refresher courses for the developing world overseas, and have attended other meetings arranged in the UK to consider the special needs of the developing world. A seminar for all those interested in working in developing countries will be held at 9 Bedford Square on 1 November 1989.

18. Editorial Board

The Board met on two occasions. Negotiations with Academic Press were concluded satisfactorily and the contract renewed for a further 4 years from January 1990. Messrs. Clays (*Bungay*) have withdrawn from journal publication and BPCC Whitefriars Ltd. (*Tunbridge Wells*) have been appointed by Academic Press to produce the journal. It is hoped that this change will avoid the two serious delays which have occurred in the distribution of the journal from Clays Ltd. Dr D.E.F. Newton (*Northwick Park*) was appointed as assistant editor in April 1989 and Dr R.M. Jones resigned his post in March 1989, due to pressure of work. Dr Jones had completed 4 years of assiduous work for the journal and the Board and the Association are grateful for his efforts.

19. Finance Committee

The Finance Committee (Chairman, Professor M. Rosen) met on two occasions during the year. The increased costs which had been forecast in the previous year were evident and it was thought essential to continue to make provision for the high level of activity which was now an established feature of the Association. The agreement to finance, jointly with the College of Anaesthetists, a post of Senior Lecturer in Intensive Care at a cost to each organisation of £30 000 annually over a 5-year period, was an example.

The Committee noted the generous donation made towards the purchase of computer equipment by Hewlett-Packard.

The Committee reviewed subscription rates for 1990 and recommended that the full ordinary subscription from July 1990 be £90 per annum with increases *pro rata* in other subscription rates.

20. Private Practice Committee

The Private Practice Committee (Chairman, Dr M.T. Inman) has met on two occasions and has been considering the recommendations of the BMA and the changes which are being suggested by the Provident Associations. The Committee has liaised closely with the Chairman of the Anaesthetic Sub-Committee of the CCHMS and with the Advisor in Anaesthesia to BUPA.

The Committee has revised Guidelines for Fees in Private Practice and these will be published with effect from January 1990.

A further seminar on the Benefits and Mechanisms of Group Practice was held at 9 Bedford Square.

21. Junior Anaesthetists' Group

The JAG Committee has met five times in the past year, including the Annual General Meeting at the University of Keele.

There have been four retirals this year. On behalf of JAG we would like to thank Dr J. Chestnut (Honorary Secretary), Dr G. Clarke, Dr J. O'Dea (*Republic of Ireland*) and Dr D. Howes (Keele ASM representative) for all the work that they have done on behalf of trainees. Details of the current membership of JAG and a regular newsletter can be found in *Anaesthesia News*. Further information can be found in the Junior Linkman Newsletter sent out after every JAG meeting.

The Annual Scientific Meeting was held at the University of Keele, Stoke-on-Trent, 5–7 April 1989. The facilities and scientific and social programmes were excellent; over 200 trainees attended. Direct canvassing through Junior Linkmen produced 12 entries for the Registrars' Prize. The first prize and President's Medal was won by Dr A.J. Martin (*Manchester*) and a second prize was awarded to Dr J. Read (*Bangour General Hospital, West Lothian*).

The Junior Linkman Scheme has just over 50 Linkmen. This is more than ever before but the aim is to have a Linkman in each rotation in the country to achieve a self-perpetuating group. As an extra incentive there will be a trial Winter Junior Linkman Seminar in Bedford Square.

This year saw the completion of four documents relating to trainees: 'Registrars in Anaesthesia—1986' (Dr Nancy Redfern), 'Guidelines on Duties of Chairman of Divisions of Anaesthesia' and 'Consultant: Trainee Relationships. A guide for consultants'. The Association's booklet, 'Handbook for the Trainee Anaesthetist', prepared by Dr Wendy Scott and Dr T.B. Boulton, is being updated; the revised edition will soon be available. All these documents have made useful contributions towards the welfare of trainees. More details are available from Linkmen.

During the past year JAG committee members have represented trainees on committees and working parties of the Association, the College of Anaesthetists and related bodies. This can only be done effectively if there is regular feedback from the trainees whose views are being represented.

22. The Anaesthetics Subcommittee of the CCHMS

The increasing number of pages which constitute the agenda, minutes and papers for consideration indicate an increasing number of concerns that are being brought to the attention of the subcommittee (Chairman, Dr J. Edmonds-Seal) by its members and by anaesthetists throughout the country. These range from concerns on differential subscription rates for medical indemnity, 'Safety Net' levels and the consequences of 'Achieving a Balance', through the holes in the White Paper, to terms and conditions of service, problems of study leave and the on-going discussions concerning the schedule of proposed anaesthetic fees produced by the Private Practice Fees Working Party of the BMA, as well as the level of fees paid to anaesthetists or proposed by independent hospitals and contractors.

Concerning medical indemnity, the subcommittee has decided to seek information from the three defence societies on major and recurrent cases for which anaesthetists are sued and to consider what advice, if any, should be given to the specialty as a result of this inquiry.

The subcommittee has drawn up guidelines on 'Safety Net' levels in anaesthesia at the request of the President of the Association of Anaesthetists which it is hoped will be helpful to members in local discussions at district and departmental levels.

Several individual cases of problems with study leave and expenses were considered by the subcommittee, which indicated a general concern within the specialty that health authorities were not funding study leave as they should. This is something of which the BMA is aware and is concerned.

The level of fees paid to anaesthetists for administering anaesthetics in general dental practice remains a matter of concern and has been brought to the attention of the BMA's Private Practice and Professional Fees Committee.

This committee has set up a Fees Working Party, and a schedule of proposed anaesthetic fees separating surgical and anaesthetic fees based on a comprehensive OPCS list of operations is at present being considered. The subcommittee has been very concerned that any new proposed scheme should not only reflect current fee levels but also incorporate sufficient flexibility to meet the circumstances of unusual cases, complex procedures, extensive pre- and postoperative involvement of anaesthetists. The subcommittee is concerned that any new schedule should not disadvantage members.

The subcommittee was pleased that the advice on personal accident and insurance for hospital call out teams was accepted by the BMA, published in the BMA Review and recently updated.

The report of the Royal College of Surgeons Working Party on the management of patients with major injuries has also been considered and some concern expressed about the implications for staffing of departments should the recommendations be implemented. It was obvious to all that the consequences needed to be properly explained, financed and realised.

23. Museum, Library and Archives Subcommittee

This subcommittee (Chairman, Dr T.B. Boulton) was formally constituted during the year with the remit of supervising the Museum and Library activities. The Museum, under the Curatorship of Dr David Wilkinson, is based on the Charles King collection but has been expanded till it now contains over 1000 items. Storage space for this collection has proved to be difficult, but liaison with the Science Museum is thought likely to be helpful in this respect. The Library, under the Curatorship of Dr Ian MacLellan, is devoted almost entirely to historical matters and the original Bryn Thomas collection of books is being expanded by judicious purchases. A most successful and expanding component of the library is the development of an archival collection of audiovisual material. Dr Audrey Eccles, the ICI Archivist/Librarian, has instituted a computerised system of cataloguing which will be compatible with that of other similar institutions and has also cooperated in producing a series of exhibitions and historical seminars throughout the year. The subcommittee has also been given the responsibility within the Association for the preparation of medals and certificates of honour and the care of the many valuable portraits and possessions within the Bedford Square headquarters.

24. Specialist Societies of Anaesthesia

The annual meeting between Officers and representatives of the specialist societies was held on 18 November 1988. There was good representation from the specialist societies. The President reviewed the Association's current activities and each representative gave a brief resumé of their society's organisation and areas of activity.

25. Working Parties

Stress Amongst Trainee Anaesthetists. The Working Party set up by Council to consider stress amongst trainee anaesthetists has published a report, 'Consultant: Trainee Relationships. A guide for consultants' (May 1989). Council gratefully acknowledges the invaluable contribution of Dr P.J. Helliwell, Chairman, and the members of the Working Party in the preparation of this important publication.

Efficiency of Theatre Services. This Working Party (Chairman, Professor M. Rosen, Immediate Past President) has continued throughout the year. Meetings and discussions have been held with representatives of many of the major surgical specialist societies with a view to producing a joint publication. In February, oral evidence was presented by the President, Dr Burrows and the Honorary Assistant Treasurer, Dr J.E. Charlton, to a Department of Health Steering Group on theatre utilisation under the chairmanship of Professor Bevan.

The main recommendations of the Working Party include the appointment of a Theatre Services Director to establish and implement guidelines for theatre utilisation, that there is close collaboration on the administrtation of waiting lists, that single specialty theatres are kept to a minimum and that a dedicated theatre is available for emergency work. The report makes recommendations about list management and utilisation, anaesthetic assessment and training and supervision of medical, theatre and support staff.

The Report of the Working Party will be published jointly by the Association of Anaesthetists and the Association of Surgeons in consultation with several other surgical specialist societies. The final draft is awaiting approval at the time of writing this report.

Assistance for Anaesthetists. The draft report of this working party (Chairman, Dr M.M. Burrows, President) was brought to the Linkman Conference last year, following which Council approved its publication. 'Assistance for the Anaesthetist' has been well received by anaesthetic departments round the country who have particularly valued its guidance on improving the pay of their assistants. We welcome the news that substantial improvements in salary and career structure for ODAs have been proposed by the management side of the Whitley Council; at the time of writing these are being considered by staff side. It is hoped that anaesthetic nurses have benefited from the nurse regrading exercise. The Working Party has continued to place evidence before the DOH Steering Group on Operating Theatre Staffing whose report is imminent.

Further detailed discussions have been undertaken with the NHS Training Authority ODA project team as they work to prepare for competence-based training for ODAs in both their basic and extended roles. The Working Party places great importance on ensuring recognition of the increasingly varied and complex tasks required to support modern anaesthetic techniques and the pressures generated by the rapidity with which emergency situations develop.

Close liaison is being maintained with nursing and ODA organisations and we would welcome feedback from members about their experiences of local training, staffing and remuneration initiatives.

High Dependency Units. As identified by the Association's survey of intensive care units, the results of which were published in August 1988 ('Intensive Care Services—provision for the future'), the present use of high dependency units throughout the U.K. is very diverse. The Working Party (Chairman, Dr J.A.W. Wildsmith), therefore, takes the view that it is the concept of high dependency *care* which requires to be considered rather than the actual structural entity of a high dependency unit. The Working Party's report will concentrate on what constitutes high dependency care, its advantages and how it may be provided.

Anaesthetic Department Design. The Building Note concerning anaesthetic department design has remained unaltered for many years. The West Midlands Regional Health Authority requested the help of the Association in bringing its guidelines for district general hospital anaesthetic departments up to date. A small Working Party (Chairman, Dr M.M. Burrows, President), met on two occasions and made recommendations that may eventually be incorporated in a new Building Note.

The Working Party recommended that the size of anaesthetic departments be based upon the number of consultant whole time equivalents. It stressed that there must be the normal provision of offices for consultant, secretarial and ancillary staff. There must be a lounge, kitchen facilities, laboratory and workshop spaces, a library and seminar room, adequate overnight accommodation for on-call personnel and appropriate space and resources for clinical audit.

The different needs of teaching hospitals were emphasised. The Working Party stressed the need to upgrade existing departments and to make provision for future developments.

Pre-anaesthetic Check Procedures This Working Party (Chairman, Professor A.P. Adams) has reviewed available information on checking procedures for anaesthetic machines from various articles, organisations and countries including the UK, Canada, Australia, the United States of America, the Netherlands and the Republic of Colombia. Check procedures from some manufacturers have also been examined. An extensive literature survey has been undertaken.

A detailed anaesthetic machine check based on the 'single hose test' takes some time (16 minutes) to perform. The Committee is anxious to produce recommendations which will be simple both to memorise and to perform and hence likely to gain widespread acceptance. The Committee is now examining a completely fresh approach to the checking of anaesthetic machines based on the presence of an oxygen analyser in order to reduce the various problems associated with the repeated coupling and decoupling of gas hoses.

Services for Chronic Pain Relief. The Association of Anaesthetists, College of Anaesthetists and Intractable Pain Society Joint Working Party (Chairman, Dr J.E. Charlton) on chronic pain relief has met on several occasions. It is proposed to offer recommendations for General Professional Training and Higher Professional Training in pain relief. It is considering the extent and content of training for anaesthetists intending to pursue a career with an interest in pain relief.

An enquiry is being carried out in four health regions of England to assess the scope of pain relief services being offered and the role of the anaesthetist in the provision of this service. From this it may be possible to make recommendations about minimum standards and facilities needed to train anaesthetists in pain relief. It is hoped to report at the end of 1989.

26. Anaesthesia Management News

The Association has introduced a bi-annual publication, edited by Professor M.D. Vickers (*Cardiff*) highlighting anaesthetic matters with implications for management. The publication is circulated to Linkmen and district general managers.

27. The Monospecialist Committee for Anaesthesia and Re-animation

During the past year the Committee for Anaesthesia (Association representative, Dr W.R. MacRae, Honorary Treasurer) has met on two occasions, once in Rome and again in Paris. The meetings were well attended with representation from virtually all EEC countries. Professor Barrier (*Paris*) was installed as President.

The Committee considered a wide range of matters including: *International Standards for Colour Coding of Cylinders and Pipelines containing Medical Gases in EEC countries.* There is general unanimity in regard to coding but several countries, namely the Netherlands, Greece and West Germany do not conform to ISO Standards. It was agreed to recommend to the UEMS that a Directive be introduced requesting all EEC countries to conform to ISO standards.

Examinations. It was proposed that a multispecialty meeting of UEMS be convened to persuade all disciplines to consider the setting of European Standards. It was suggested that there should be a joint meeting with the European Academy of Anaesthesiologists to consider the matter.

Visits to training centres. As an introduction to the concept of 'visiting' training centres throughout the EEC countries, it was noted that two centres had offered themselves to receive such visits by selected visitors. It was also proposed that the College of Anaesthetists be invited to permit a small number of senior anaesthetists from EEC countries to have an opportunity to attend a hospital visit in the United Kingdom to acquaint themselves with the format of such visits.

Assistance for Anaesthetists. It was agreed to undertake a survey of the methods whereby skilled assistance was provided for anaesthetists throughout the EEC countries in an attempt to achieve some uniformity of practice.

Appendix A

Composition of Council, its Subcommittees and Working Parties

Council

Five Meetings held (Attendance in brackets).

Officers: Dr M.M. Burrows, President (5); Professor M. Rosen, Immediate Past President (4); Dr R.S. Atkinson, Vice-President (4); Dr M.T. Inman, Vice-President (5); Dr J.F. Nunn, Vice-President (4); Dr W.L.M. Baird, Honorary Secretary (4); Dr W.R. MacRae, Honorary Treasurer (5); Dr P. Morris, Immediate Past Honorary Secretary (4); Dr J.E. Charlton, Assistant Honorary Treasurer (4); Dr J.N. Lunn, Editor (5).

Elected Members: Dr D.S. Arthur (3); Dr K. Budd (5); Dr J. Edmonds-Seal (5); Dr Margaret L. Heath (5); Professor P. Hutton (2); Dr S.M. Lyons (5); Dr R.L. Marks (5); Dr W.S. Nimmo (2); Dr R.M. Weller (5); Dr J.A.W. Wildsmith (5); Dr D.L. Paul, JAG (4); Dr R. Jane Chestnut, JAG (2), until April 1989; Dr P.J. Heath, JAG (2), since April 1989.

Co-opted Members: Professor A.P. Adams; Dr P.J.F. Baskett; Air Commodore C.A.B. McLaren; Dr D.C. Moriarty; Dr D. Riordan; Professor M.K. Sykes; Professor M.D. Vickers; Dr J.S.M. Zorab.

Advisory Committee

Five meetings held (attendance in brackets).

Chairman: Dr M.M. Burrows (5); Professor M. Rosen (4); Dr W.L.M. Baird (5); Dr W.R. MacRae (5); Dr P. Morris (5); Dr J.E. Charlton (5); Dr J.N. Lunn (5); Dr Margaret L. Heath (3); Dr W.S. Nimmo (1); Dr J.A.W. Wildsmith (5); Dr D.L. Paul, JAG (5).

Editorial board

Chairman: The President; *Editor:* Dr J.N. Lunn; *Associate Editor:* Dr M. Morgan; *Assistant Editors:* Professor A.R. Aitkenhead, Dr G. Greenbaum, Dr R.M. Jones, until December 1988, Dr D.E.F. Newton, since January 1989.

Editor, Anaesthesia News: Dr J.N. Horton. Dr C.F. Scurr. *Representatives of Council:* Dr P.J.F. Baskett, Dr J. Edmonds-Seal, a representative of the Junior Anaesthetists' Group. *Co-opted Members:* Mr E. Warburton (Honorary Financial Adviser) Miss Joan Fujimoto (Academic Press), Miss Jane Lawrence (Academic Press).

Education and Research Committee

Dr W.S. Nimmo, (*Chairman*) Dr Margaret L. Heath, Professor P. Hutton, Dr S.M. Lyons, Dr R.L. Marks, Dr J.F. Nunn, Dr J.A.W. Wildsmith, Dr D.L. Paul, JAG.

Safety Committee

Professor A.P. Adams, (*Chairman*), Dr D.S. Arthur, Dr K. Budd, Dr J.A. Bushman, Dr R. Greenbaum, Dr P.J. Heath (Junior Anaesthetic Group), Professor P. Hutton, Air Commodore C.A.B. McLaren, Dr N.I. Newton, Professor M.K. Sykes, Dr P.W. Thompson, Dr R.M. Weller, Dr K. Allsopp (Medical Defence Union), Mr L.W. Arrowsmith (Department of Health), Mr C. Bray (Department of Health), Dr Juliet K. Davies (Medical Protection Society), Mr M. Freeman (Chairman, BAREMA), Dr I.G. Simpson (Medical and Dental Defence Union of Scotland), Dr Helen Sutton (Department of Health).

International Relations

Dr M.T. Inman (*Chairman*), Dr J.A. Bushman, Dr G. Clarke JAG, Dr M. Dobson, Dr R.J. Eltringham, Dr S.M. Lyons, Dr R.L. Marks, Dr M.W. Platt, JAG, Professor M. Rosen, Dr R.M. Weller, Dr J.S.M. Zorab, (President, WFSA).

Representatives from:
Overseas Development Administration, Bureau for Overseas

Medical Service, British Council, Voluntary Services Overseas, Appropriate Health Resources and Technologies Action Group.

Finance Committee

Professor M. Rosen (*Chairman*), Dr K. Budd, Dr J. Edmonds-Seal, Dr R.L. Marks, Mr E. Warburton (*Honorary Financial Adviser*).

Private Practice

Dr M.T. Inman (*Chairman*), Dr D.S. Arthur, Dr P.J.F. Baskett, Dr K. Budd, Dr E.B. Lewis, Dr I. Verner.

Specialist Societies

President (*Chairman*).

Representatives from:
Age Anaesthesia Association, Association of Cardiothoracic Anaesthetists, Association of Dental Anaesthetists, Association of Paediatric Anaesthetists of Great Britain and Ireland, College of Anaesthetists, Computing in Anaesthesia Society, European Society of Regional Anaesthesia—U.K. Committee, History of Anaesthesia Society, Intractable Pain Society of Great Britain and Ireland, Junior Anaesthetists Group, Neuroanaesthetists' Travelling Club, Obstetric Anaesthetists' Association, Plastic Surgery and Burns Anaesthesia.

Museum, Library and Archives Subcommittee

Dr T.B. Boulton (Honorary Archivist and Chairman), Dr D.J. Wilkinson (*Honorary Curator, Charles King Collection of Historical Apparatus*), Dr I. McLellan (*Honorary Librarian*), Dr Audrey Eccles (*I.C.I. Archivist/Librarian*).

Anaesthetics, Subcommittee of the CCSC (formerly CCHMS)

Dr J. Edmonds-Seal (*Chairman*), Dr W.L.M. Baird, Dr P. Morris, Dr. S.M. Lyons, Dr D. Laird (JAG).

Junior Anaesthetists' Group

Dr D.L. Paul (*Chairman*), Dr R. Jane Chestnut (*Secretary*), until April 1989, Dr P.J. Heath after April 1989, Dr A. Skidmore (*Vice Chairman*), Dr P. Morris (*Council representative*), Dr A. MacKenzie, Dr D. Laird, Dr I. McMenemin, Dr J. Owens, Dr. M. Platt, Dr I. Shephard, Dr H. St. John Gray, Dr Elizabeth Spencer.

Technical Exhibitions' Co-ordinator

Dr R.S. Vaughan.

UEMS Representative

Dr W.R. MacRae.

Resuscitation Council UK

Dr P.J.F. Baskett.

Manpower Advisory Panel

Dr J. Edmonds-Seal, Dr Elizabeth Spencer (JAG).

City and Guilds (ODA Training Committee)

Dr M.T. Inman.

Joint Committee for Higher Training of Anaesthetists

Dr P. Morris, Dr W.L.M. Baird, Dr P.J. Heath (JAG).

Working Party on Pre-anaesthetic Check Procedures

Professor A.P. Adams (*Chairman*), Dr P. Bickford-Smith, Dr J.D. Henville, Dr N.I. Newton, Dr M.W. Platt (JAG).

Joint Working Party on Chronic Pain Relief Services

Dr J.E. Charlton (*Chairman*), Dr K. Budd, Dr A.W. Diamond (*Intractable Pain Society*), Dr F.R. Ellis (*College of Anaesthetists*), Dr P.J.D. Evans (*Intractable Pain Society*), Dr D.J. Hatch (*College of Anaesthetists*), Dr R.L. Marks.

Working Party on Efficiency of Theatre Services

Professor M. Rosen (*Chairman*), Dr Margaret L. Heath, Dr E.B. Lewis, Dr J.R.E. Jenkins, Dr A.F. Naylor, Dr A.M. Reid, Dr J.S.M. Zorab.

Working Party on Stress Amongst Trainees in Anaesthesia

Dr P.J. Helliwell (*Chairman*), Dr M.P. Coplans (*Secretary*), *Representatives of Council:* Dr P.J.F. Baskett, Dr J. Edmonds-Seal, Dr M.T. Inman, Dr J.F. Searle, Professor G. Smith, *Representatives of Faculty Tutors, nominated by the Dean:* Dr Angela M. Mackersie; Dr M.A. Rucklidge; *Representatives of JAG:* Dr G.W. Hamlin (Immediate Past Chairman, JAG), Dr A.D.J. Nicholl (Immediate Past Secretary, JAG), Dr A. Skidmore. *By invitation of the Chairman:* Dr Chandy Verghese, Miss Jenny Firth-Cozens.

Working Party on Assistance for Anaesthetists

Dr M.M. Burrows (*Chairman*), Dr Margaret L. Heath (*Secretary*), Dr D.S. Arthur, Dr J. Edmonds-Seal, Dr. M.T. Inman, Dr S.M. Lyons, Professor M.D. Vickers.

Joint Association/College Working Party on Adverse Drug Reactions Reporting

Association representatives: Dr W.S. Nimmo, Dr W.L.M. Baird, Dr J.A.W. Wildsmith. *College representatives:* Professor A.A. Spence, Professor C.J. Hull, Professor J.W. Dundee.

The executive officers of the Association are ex-officio members of all committees and working parties above.

Appendix B

Association Linkmen

Names are grouped according to Regional Health Authority (Area in Scotland); the order of names within each group is arbitrary and without significance.

England

Northern (R.H.A. 1)

D.J.H. Daniel (*Hartlepool*); B. Dennison (*South Teeside*); R. Goodwin (*Durham*); D.C. Townsend (*South West Durham*); K.S. Cameron (*North West Durham*); C. Beeton (*Darlington*); I. Anderson (*Hexham*); D.J. Greaves (*Ashington*); M.R. Bryson (*Newcastle Central Sector*); S.K. Greenwell (*North Tyneside*); S. Srivastava (*South Tyneside*); R.P. Harpin (*Newcastle Western Sector*); P. Copeland (*Newcastle Eastern Sector*); G. Harris (*North Tees*); R.M. Freeman (*Cumbria*); A.E. Brown (*Gateshead*); G. Earnshaw (*Barrow-in-Furness*); B.B. Bhala (*South Shields*); M.K. Johnson (*Sunderland*); J.N. Hodkinson (*South Cumbria*); D.M. Watson (*West Cumbria*).

Yorkshire (R.H.A. 2)

T.D. Biswas (*Pontefract*); S. Firn (*Wakefield*); S. Swindells (*St James' University Hospital*); T.M. Jack (*Leeds General Infirmary*); M. Bembridge (*Huddersfield*); A.F. Stakes (*Halifax*); S.G. Jones (*Airedale*); M.J. Wade (*Bradford*); G.J. MacWhirter (*Harrogate*); R.G. Wheatley (*York*); G.T. Whitfield (*Scarborough*); D.P. Winder (*Hull*); J.M. Clark (*Grimsby*); P.J. Bickford-Smith (*Leeds*).

Trent (R.H.A. 3)

D.P. Cartwright (*Derby*); J.V.B. Mundy (*Royal Hallamshire Hospital, Sheffield*); J. Hunsley (*Northern General Hospital, Sheffield*);

P.J. Mawson (*Rotherham*); B. Milne (*Doncaster*); P.S. Gadgil (*Barnsley*); C.D.D. Hutter (*Nottingham*); A.J. Whittaker (*Mansfield*); J.F.W. Thompson (*Scunthorpe*); A.H.R. Spong (*Lincoln*); A.G. Cole (*Leicester*); M.J. Wolfe (*Chesterfield*); P. Smith (*Worksop*); M. Bexton (*Boston*); J.S. Mason (*Newark*).

East Anglia (R.H.A. 4)

P. Gray (*Bury St. Edmunds*); P.J. Keep (*Norwich*); S.G. Harrison (*Ispwich*); J.R.O. Jenkins (*Great Yarmouth*); R.N. Francis (*King's Lynn*); P. Bennison (*Papworth*); C.W. Glazebrook (*Cambridge*); E. A. Maher (*Bury St. Edmunds*); G.G. Crabbe (*Peterborough*).

North West Thames (R.H.A. 5)

K.P. Kyriakou (*Ealing*); D.J.C. Robinson (*St. Mary's*); R.L. Hargrove (*Westminster*); W.J. Hegarty (*Hillingdon*); P. Chakrabarti (*West Middlesex*); M. Meurer-Laban (*King Edward VII, Ealing*); J. Lumley (*Hammersmith*); J. Stevens (*Charing Cross*); D.C. White (*Northwick Park*); E.S. Walsh (*Central Middlesex*); A.E. Nichol (*Barnet*); S. Jothilingham (*Stevenage*); M.I. Carter (*Luton*); J. Hurst (*Bedford*); G.M.D. Archer (*Royal Marsden Hospital*); G.M. O'Sullivan (*Watford*); Z.P. Shah (*Welwyn Garden City*); M.I. Boscoe (*Ealing*); N. Poobalasingam (*Haringey*); W.J. Rickford (*Hertfordshire*).

North East Thames (R.H.A. 6)

A.R. Deacock (*Royal National Orthopaedic*); J. Ormrod (*University College Hospital*); D. B. Ellis (*St. Peter's and St. Paul's*); D.J. Wilkinson (*St. Bartholomew's Hospital*); J.D. Hill (*Epping*); P.J. O'Shea (*The London Hospital*); S.A.I. Helwa (*Enfield*); M.S. Pegg (*Royal Free*); P.M. Bashir (*Barking*); G.B. Rushman (*Southend*); P.O. Bodley (*Romford*); R.W. Griffin (*Colchester*); R.A. Spilsbury (*Chelmsford*); J.L. Handy (*Mid-Essex*); D.A. Thomas (*Harold Wood Hospital*); E.P. Gibbs (*Essex*); E. Javed (*Barkingside*); S.K. Hepton (*Brentwood*); D.V.A. Kalmanovitch (*Royal Free*).

South East Thames (R.H.A. 7)

B.C. Bradburn (*Kent*); A.R. Thompson (*Hastings*); B. Steer (*Eastbourne*); E.A. Proctor (*Canterbury*); E.B. Lewis (*Ashford*); H. Singh (*Dartford*); P.E. Daly (*Greenwich*); M.A. Thompson (*Lewisham, North Southwark and Guy's Hospital*); I.M. Corall (*King's College*); J.A. Mathias (*St. Thomas's*); C.J. Barham (*Kent & Sussex*); F.E. Bennetts (*Medway*); E. Sumner (*Great Ormond Street*); N. Fletcher (*London*); N.G. Fisher (*Hove*).

South West Thames (R.H.A. 8)

B.M. Dempsey (*Ashford*); W.A.L. Rawlinson (*Cuckfield*); R.C. Brookes (*Croydon*); J.R. Fozard (*Guildford*); D.A. Wright (*Kingston upon Thames*); H.R. Waters (*Worthing*); J.C. Missen (*Chichester*); J.F. Lees (*Sutton & West Merton*); A.C. Thurlow (*St. George's*); A.M. Rollin (*Epsom*); I. Sutherland (*Frimley Park*); D.A. Young (*Caterham*); R. Ratcliffe (*East Surrey Hospital*); L. St. John Jones (*Crawley*); C.J. Moon (*Crawley*); I.K. Stanley Jones (*Surrey*).

Wessex (R.H.A. 9)

I. Spencer (*Wiltshire*); K.J. Gill (*West Dorset*); R.W.D. Clunie (*Winchester*); A.D. Logan (*Isle of Wight*); P.W.R. Smethurst (*Salisbury*); D.M. Jackson (*Swindon*); D.T. Protheroe (*Bath*); A. Turrall (*Portsmouth*); J.H. Winder (*Southampton*); S.S. Barker (*Aldershot*); K. Landon (*Newport*); P.J. James (*Basingstoke*).

Oxford (R.H.A. 10)

J.P. Sale (*Aylesbury*); M.E. Ward (*Oxford*); A.B. Lodge (*Northampton*); N. Allison (*High Wycombe*); M.D.G. Bukht (*East Berkshire*); T.G. Smith (*Reading*); M.J. Cowen (*Milton Keynes*); B.A. Thornley (*Banbury*); C.R. Eatock (*Oxfordshire*); J. Freeman (*Kettering*).

South Western (R.H.A. 11)

R.W. Johnson (*Bristol*); J.A. Bennett (*Frenchay Hospital, Bristol*); J.T. Mulvein (*Southmead Health District, Bristol*); G. Jephcott (*Weston-super-Mare*); C. Harvey (*Cornwall and IOS Health Authority*); G. Sowden (*Barnstaple*); W.B. Clarkson (*Exeter*); J.L. Thorn (*Torquay*); R.H.M. Hodgson (*Plymouth*); A.N. Burlingham (*Cheltenham*); F.G. Hall (*Yeovil*).

West Midlands (R.H.A. 12)

M.D. Milne (*Wolverhampton*); A. Leslie (*Walsall*); A. Patel (*West Bromwich*); V. Gnanadurai (*Stourbridge*); M.A.H. Lewis (*Coventry*); E.R.S. Hooper (*Good Hope*); J.M. James (*Birmingham*); J. Hurdley (*Selly Oak*); K.K. Dutt (*Dudley Road*); A.P.F. Jackson (*Queen Elizabeth*); T.H. Spreadbury (*Warwick*); W.N. Ramsden (*Stoke-on-Trent*); C.T. Major (*Shrewsbury*); P.V. Scott (*Bromsgrove*); I.P. Hine (*Hereford*); N.S. Kaduskar (*Nuneaton*); J.W. Martin (*Burton on Trent*); C.D. Maile (*Worcester*).

Mersey (R.H.A. 13)

R.G. Snow (*Chester*); J.S. Sprigge (*Wirral*); E.C. Howard (*Walton Hospital, Liverpool*); R.P. Howard (*Whiston and St. Helen's*); T.H.L. Bryson (*Liverpool*); E. Duane (*Warrington*); R.F. Graham (*Macclesfield*); W.F. White (*South Wirral*); C.L. Charway (*Southport*); M.G.D. Salem (*Halton General Hospital*); R.M. Clark (*Crewe*).

North Western (R.H.A. 14)

I.W. Jones (*Wigan*); S.V. Lees (*Trafford*); J.H. Wright (*Tameside*); S. Remington (*Stockport*); C.C. Spanswick (*Salford*); P.M. Burridge (*Rochdale*); H.L. Goldwater (*Manchester North*); J.H. Breed (*Manchester South*); B. Foster (*Manchester Central*); N.H. Naqvi (*Bolton*); W.A. Noble (*Preston*); K.M. Natrajan (*Blackpool*); M.A. Rucklidge (*Lancaster*); S. Mehta (*Burnley*); D.J.A. Rose (*Blackburn*); J.P.D. Friend (*Ormskirk*); R.M. Doshi (*Oldham*); W.A. Thomas (*Wythenshawe*); V.K. Aggrawala (*Bury*).

Wales

W.O. Roberts (*Caernarvonshire and Anglesey General Hospital*); G.D. Thomas (*Gwent*); D.H. Long (*West Glamorgan*); D.E.N. Evans (*Cardiff*); J.C. Sumption (*Pontypridd*); M. Turtle (*Carmarthen*); G.J. Arthurs (*Wrexham*); C.F. Bell (*Clwyd North*); R.G. Mucklow (*Aberystwyth*); L.S.I. Pathiratne (*Pembrey*); R.W. Morris (*Bridgend*); R. Bose (*Neath*); W.J.W. Thomas (*Clwyd*).

Scotland

Highland

J.D. Muir (*Inverness*).

Grampian

J.S. Blaiklock (*Aberdeen*); G.M. Duthie (*Elgin*).

Tayside

P.B. Taylor (*Dundee*); A.A. Kutarski (*Perth*).

Fife

D.C. Wilson (*East Fife*); J.A. Duncan (*West Fife*).

Borders

S.J.B. Robertson (*Peel Hospital*).

Lothian

L.V.H. Martin (*Edinburgh Royal Infirmary*); J.L. Jenkinson (*Western General Hospital*); J.C. McIntyre (*City Hospital and Southern Group*); N.A. Malcolm Smith (*Princess Margaret Rose Orthopaedic Hospital*).

Glasgow

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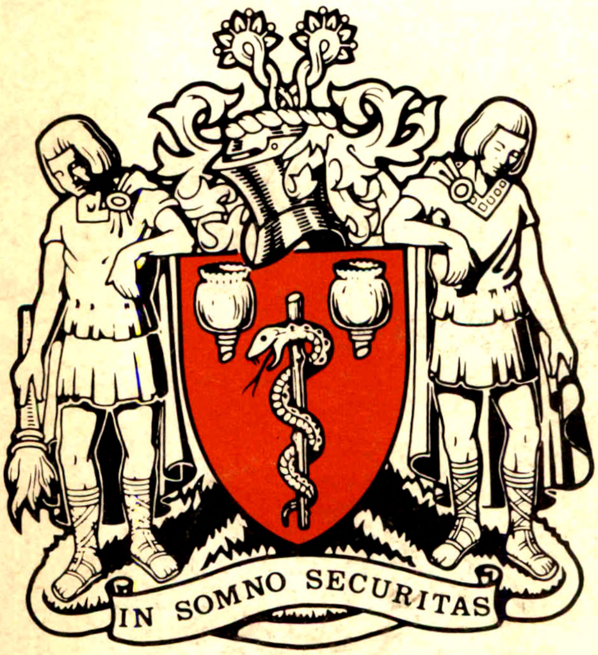

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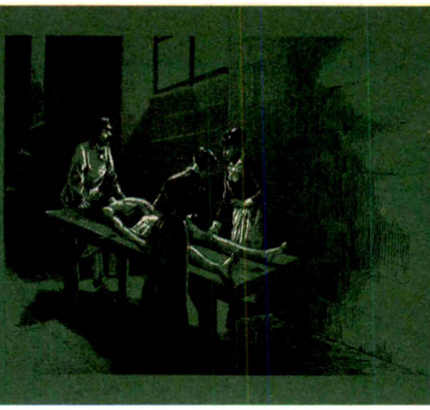

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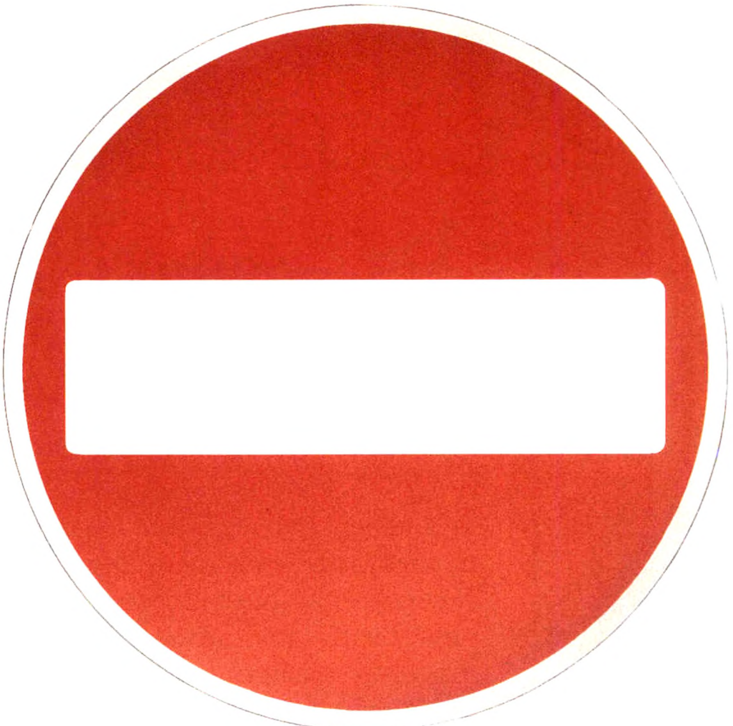

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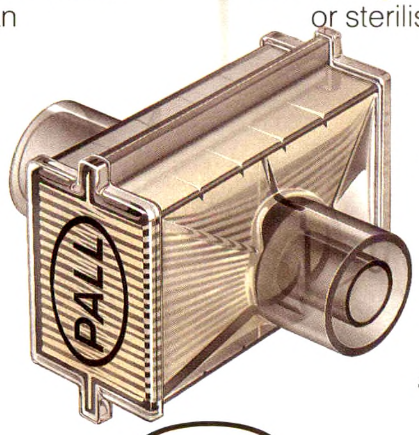

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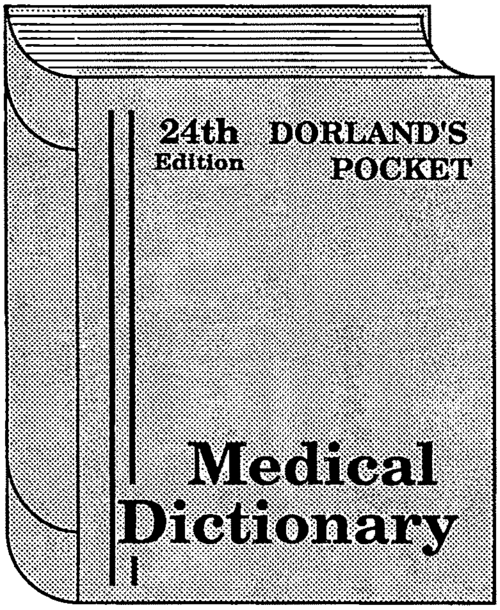

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Editorial

Implications of nervous system plasticity for pain management

This is an exciting time in neuroscience, and some of the recent developments have implications for the way in which we manage pain.[1] The most important concept is that the nervous system is not a hard-wired, line-labelled system, but instead is capable of plasticity, the ordered alteration of structure or function due to development, experience or injury. Clinically we use the hard-wired, line-labelled concept successfully in pain treatment, as when local anaesthetic is injected to block conduction reversibly, and explain our success on the basis of blockade of relevant conduction pathways. However, a hard-wired, line-labelled view of the nervous system is inadequate in other clinical pain contexts to explain what we see. Two examples are the recurrence of pain after cordotomy (after initial success), and the existence of phantom limb pain, which may be described graphically by the patient as exactly the same pain which was felt in the severed limb at the time of the accident or just before the amputation. Neither of these examples can be explained without the idea that the nervous system can change, re-establishing pain inputs, perhaps remembering painful events and indeed causing further pain due to maladaptive plasticity as in the case of painful neuromata.

It is difficult and perhaps premature to try to draw together phenomena found in different components of the nervous system into a coherent story. The reason for trying is that several themes emerge with direct relevance to management of acute pain, neurolytic procedures and for pains resistant to conventional analgesics.

Much more may be happening in the nervous system during acute traumatic, intra- or postoperative pain than simple input of a pain signal. Recordings from spinal cord dorsal horn neurones showed that the response to injury included altering the receptive field of the neurone. Injury may also induce a hyperexcitable state, called wind-up, in the dorsal horn neurones, in which constant peripheral input sequentially increases activity. This wind-up may relate to a 'pain memory', and blocking or reducing this process may result in more effective analgesia, both at that time and subsequently. This speculation is based on a common pharmacological process in both spinal cord wind-up and in the hippocampus, where a short burst of activity can induce prolonged increased excitability of pathways, or long-term potentiation (LTP).[2] This common process involves the N-methyl-D-aspartate (NMDA) subclass of the receptors for the excitatory amino acids (glutamic and aspartic). Hippocampal LTP is suggested as a plausible substrate for memory,[2] and NMDA receptors appear to be pivotal in its genesis.

NMDA antagonists in the spinal cord can reduce or abolish wind-up,[3] and the NMDA receptor complex may be involved in sustaining or even magnifying pain transmission in the cord, particularly when the pain input is declining in the peripheral nerves. The outcome may be reduced sensitivity to morphine-like drugs compared with normal nociceptive input.[4] There is also evidence that the pain input can result in intracellular change and gene induction. Staining for the gene marker c-fos showed that noxious stimulation for a 30 to 60-minute period could induce proto-oncogenes in the adult;[5] the consequences of such changes for the nociceptive pathways could be far-reaching.

The clinical implication of these findings is that 'preventing' pain or reducing its impact may make subsequent management easier,[6] the idea being that reducing the nociceptive input will reduce the scale of the plasticity changes. Two clinical examples have been used to support this argument.[6] The first was a study which showed that opioid premedication and local anaesthetic blocks both delayed significantly the time at which patients needed postoperative pain relief.[7] Construed as minimising the nociceptive input of surgery, these manoeuvres reduced the subsequent analgesic requirement. A more striking example was the observation that when ischaemic limb pain was treated adequately before amputation the incidence of phantom limb pain was reduced.[8] Patients having elective amputation for ischaemic disease either had 3 days of epidural analgesia or conventional intramuscular opioids. The incidence of phantom pain was significantly reduced in the epidural group. The clinical evidence and the plasticity findings do provide a rationale for prophylactic pain management, which is to make postoperative pain control easier. Whether the morbidity is sufficiently low to justify what is at present a solely humanitarian gain remains to be seen.

A further twist to this tale comes from the idea that different drug classes have at least additive analgesic effects but with distinct primary mechanisms. Simultaneous use of morphine and nonsteroidal anti-inflammatory drugs (NSAID) is common in cancer pain management. Recently in acute pain the combination of opioid, local anaesthetic and NSAID was found necessary to maintain pain intensity scores at zero.[9] Additive analgesic effects of opioid and local anaesthetic drugs have been shown in animal studies.[10] The suggestion is that the triad of opioid, local anaesthetic and NSAID is necessary to produce maximal reduction in pain intensity.

Anaesthetists working in the field of chronic pain are often the clinicians required to perform, or refer patients for, 'permanent' nerve blocking manoeuvres, neurolytic injection, radiofrequency or surgery. The relevance of the plasticity concept to these clinical decisions is that *long-term analgesia from such procedures is inherently unlikely*. Pains which return after successful blocks or surgery may be very difficult to treat, so the moment in the patient's illness at which these procedures are done is then critical. Performed too early the pain may recur,

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and it may be necessary to repeat the intervention, knowing that such repeat carries the risk of lower efficacy and higher morbidity.

Pains which respond poorly to opiates, opioids or other conventional analgesics are commonly chronic and are difficult to treat. Recent evidence provides us with some useful clues for pharmacological management. Such pains are commonly associated with nerve damage. Rhizotomy results in loss of half the opioid receptors on the degenerated afferent nerve terminals, but loss of receptors may not be the sole cause of the poor response to opioids. Both established central hyperexcitability and wind-up involve activation of the NMDA receptor and are less sensitive to morphine-like drugs than normal nociceptive input.[4] As in acute pain, these changes can be pre-empted by opioid pretreatment.[11] The activation of neurotransmitters able to modulate opioid actions may also alter opiate dose-response. The peptides cholecystokinin and FMRFamide are both found in spinal neurones as is the opioid peptide dynorphin, the *kappa* receptor ligand. Exogenous use of these nonopioid peptides selectively blocks the effects of morphine. Concentrations of both dynorphin and its messenger RNA are raised in inflammation, and, because *kappa* agonists can antagonise the effects of *mu* agonists, raised concentrations would reduce the efficacy of morphine, altering the opioid dose-response.

The evidence suggests that for optimal pain relief of acute pain we need to try to stop any change occurring at the NMDA receptor complex. These changes have already happened in chronic pain, and the target for pharmacological management of pains resistant to conventional analgesics is to reverse them. Some drugs in clinical use have effects at this site; ketamine at subanaesthetic doses blocks the channel (*sigma*) associated with the NMDA receptor and this may underlie its analgesic effect. The action of both anticonvulsants, as in the management of trigeminal neuralgia, and antidepressants may be at this site.

Just as better acute pain control may be achieved by blocking three primary nociceptive mechanisms rather than any one,[9] the coexistence of two or more neurotransmitters per neurone means that any single pharmacological magic bullet may be unlikely to achieve analgesia in these difficult pains. If the different neurotransmitters can be made, released or destroyed at different rates, there is considerable scope for the nervous system to alter response to repeated stimuli. Coexistence therefore suggests that strategies for pharmacological management based on drugs which block all the transmitters may be more successful than those based on antagonism of one specific transmitter alone. Morphine provides such a general block of neurotransmitter release, and nonselective first-generation tricyclic antidepressants appear to be more successful in the relevant chronic pain context than their selective descendants.[12]

The evidence from basic science together with clinical observation suggests a more hopeful outlook for improving pain management than was perceived even five years ago.

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Editorial notices

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Anaesthesia, 1990, Volume 45, pages 103–109

Delayed detection of hypoxic events by pulse oximeters: computer simulations

F. VERHOEFF AND M. K. SYKES

Summary

There is a variable delay between a reduction in alveolar $P\text{O}_2$ *and the decrease in arterial oxygen saturation recorded on a pulse oximeter. The decrease in arterial oxygen saturation in response to disconnexion of a paralysed patient from the breathing system, oxygen supply failure with continued mechanical ventilation and disconnexion of the fresh gas supply to Mapleson D and circle absorption breathing systems were studied by simulations on the MacPuf computer model of the cardiorespiratory system. The simulations revealed that there were marked differences between the rate of arterial desaturation which resulted from each of the three types of oxygen supply failure and that arterial oxygen saturation may reach dangerous levels before a pulse oximeter alarm is activated.*

Key words

Oxygen; saturation.
Measurement techniques; pulse oximetry.

The pulse oximeter is now recognised to be an essential monitor during anaesthesia.[1-3] However, the accuracy of measurement may be affected by movement, external sources of electromagnetic radiation, reduced pulse pressure, dark nail varnish, intravascular dyes, bilirubin, large venous pulsations and the presence of abnormal haemoglobins. Furthermore, Severinghaus and Naifeh[4] have shown that when finger probes are used on subjects with peripheral vasoconstriction there may be a delay of over 60 seconds before the pulse oximeter responds to a rapid change in alveolar oxygen concentration. The response time may be doubled or trebled with some instruments when finger blood flow is reduced by venous congestion or cold.[5]

Most anaesthetists set the alarm limit on the pulse oximeter at an oxygen saturation of 90%. However, the arterial saturation may have decreased to much lower values before the pulse oximeter alarms if there is a measurement delay of over 60 seconds between the decrease in alveolar oxygen concentration and the pulse oximeter response. We have therefore examined the rate of decrease of arterial oxygen tension ($P\text{aO}_2$) and saturation ($S\text{aO}_2$) which result from various causes of oxygen supply failure using computer simulations on the MacPuf model of the respiratory system.[6] The clinical situations examined were: disconnexion of the paralysed patient from the ventilator during controlled mechanical ventilation (CMV); oxygen supply failure and continued CMV with a gas that contained no oxygen in a nonrebreathing system; and a sudden decrease of the fresh gas flow to zero with a Mapleson D system and with a circle CO_2 absorption system.

It was assumed in all these simulations that the patient's lungs were initially ventilated to achieve normocapnia with an inspired oxygen concentration of 30%.

Methods

Computer simulations

The standard MacPuf 70-kg subject with an oxygen consumption of 250 ml/minute and a CO_2 output of 200 ml/minute was ventilated mechanically with a tidal volume of 500 ml and a frequency of 12 breaths/minute. The inspired oxygen concentration was set to 30% and all simulations started when a steady state had been achieved with an alveolar $P\text{O}_2$ ($P\text{AO}_2$) of 22.4 kPa and arterial blood gases ($P\text{aO}_2$ and $P\text{aCO}_2$) of 20.0 and 5.3 kPa respectively. The clinical situations were simulated in three ways.

Disconnexion of the paralysed patient from the ventilator was simulated by switching frequency and tidal volume to zero. This simulation was performed with a

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Table 1. Initial values in MacPuf program. Inspired oxygen concentration 30%, FRC 3.0 litres.

Time	Partial pressures (kPa)		Contents (ml/100 ml)		Amounts in ml			
0.0	O_2	CO_2	O_2 (STPD)	CO_2	O_2 (STPD)	CO_2	pH	Bicarbonate (mmol/litre)
Arterial	20.0	5.3	20.1	47.0	20.1	475	7.40	23.6
Alveolar	22.4	5.3	—	57.0	5.7	145	—	—
Pulmonary capillary	22.4	5.3	20.2	47.0	—	—	—	—
Brain/CSF	3.6	7.2	9.2	57.2	18.0	692	7.33	22.7
Tissue/ECF	5.5	(6.1)	14.8	51.2	185.0	13 396	7.37	—
Mixed venous	(5.5)	(6.1)	15.0	51.4	447.0	1542	7.37	25.4

O_2 uptake = 250 ml/minute
Total ventilation = 6.0 litres/minute
Deadspace = 142 ml
Cardiac output = 4.8 litres/minute
Cerebral blood flow = 46 ml/minute/100 g tissue

CO_2 output = 200 ml/minute (STPD)
Alveolar ventilation = 4.3 litres/minute (BTPS)
Tidal volume = 500 ml (BTPS)
Plasma lactate = 1.0 mmol/litre

Expired RQ = 0.80
Respiratory rate = 12.0 breaths/minute
V_D/V_T ratio = 0.28
Venous admixture = 1.5%

Table 2. Changes in arterial saturation (Sao_2) and brain Po_2 (Pbo_2) with different interventions.

Intervention	FRC (litres)	Breathing system (litres)	Time to 90% Sao_2 (minutes)	Sao_2 (%)		Maximum Pbo_2 (kPa)	Time (minutes) to maximum Pbo_2	Duration of Pbo_2 above baseline
				+1 minute	+2 minutes			
Disconnexion from ventilator (apnoea)	1.5	—	1.1	65	32	5.5	1.2	2.4
	3.0	—	2.5	66	34	5.7	2.4	3.8
Continued CMV with 0% O_2	1.5	—	0.3	<20	—	—	—	—
	3.0	—	0.5	45	—	—	—	—
Disconnexion of fresh gas supply	1.5	2.0	2.5	65	33	5.7	2.6	3.6
	1.5	5.0	4.6	75	53	4.5	5.0	6.0
	3.0	5.0	5.4	77	58	4.6	6.0	7.0
T = 40°C	1.5	5.0	3.0	73	47	5.6	3.4	4.6

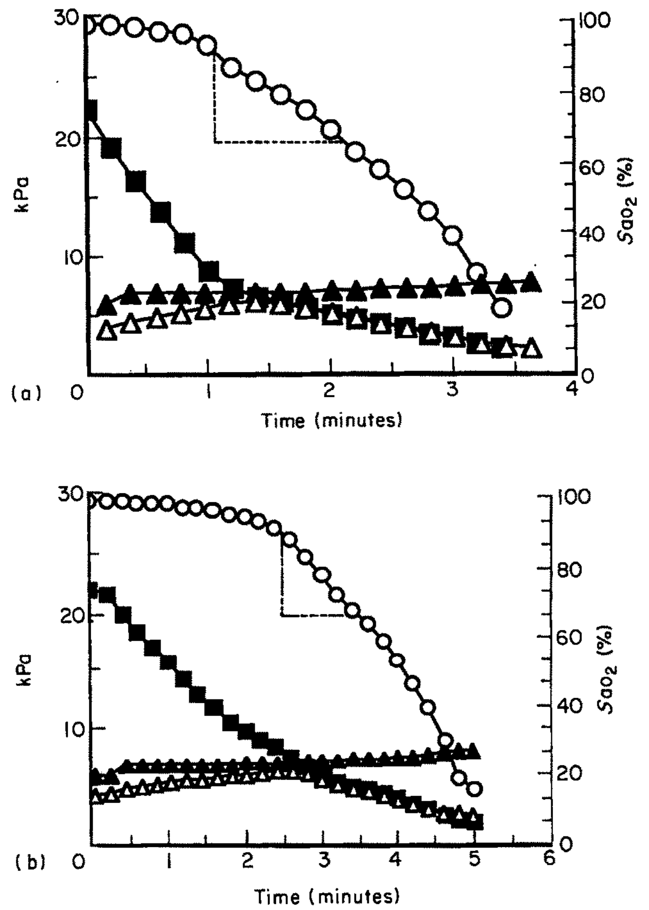

Fig. 1. Changes in arterial oxygen saturation (Sa_{O_2}; -O-), arterial P_{CO_2} (Pa_{CO_2}; -▲-), alveolar P_{O_2} (PA_{O_2}; -■-) and brain P_{O_2} (Pb_{O_2}; -△-) in response to apnoea. Inspired oxygen concentration 30%. (a) FRC 1.5 litres, (b) FRC 3.0 litres. The vertical dotted line represents the time at which 90% saturation occurs and the horizontal line shows the saturation one minute later.

functional residual capacity (FRC) of (a) 1.5 litres and (b) 3.0 litres.

Oxygen supply failure with a continued supply of a hypoxic gas mixture into a nonrebreathing system was simulated by switching the inspired oxygen concentration from 30% to zero during CMV with an FRC of 1.5 litres and 3.0 litres. This simulation assumed that the supply of the hypoxic gas mixture exceeded the patient's minute volume.

The disconnexion of a breathing system from a fresh gas supply was simulated by switching to rebreathing with a bag of 2 litres volume without CO_2 absorber (to simulate continued ventilation with a Mapleson D or Bain system) and by switching to a 5-litre bag with CO_2 absorber (to simulate continued ventilation with a circle CO_2 absorption system). The circle CO_2 absorption system simulation was performed with FRC values of 1.5 litres and 3.0 litres. A further simulation was performed with an FRC of 1.5 litres but a body temperature of 40°C to study the effects of increased oxygen consumption.

Results

The initial values during CMV on 30% oxygen are shown in Table 1 and a summary of the main features of the simulations in Table 2.

Disconnexion from the ventilator (a) FRC 1.5 litres, (b) FRC 3.0 litres

The rate of decrease of Pa_{O_2} was greater with an FRC of 1.5 litres than with an FRC of 3.0 litres and the time taken to reach an Sa_{O_2} of 90% was approximately twice as long with a large FRC (Fig. 1a and b). Thereafter the rate of decrease of Sa_{O_2} was similar; the Sa_{O_2} values were 65 and 66% one minute later and 32 and 34% 2 minutes later with the 1.5-litre and 3.0-litre FRC respectively. Pa_{CO_2} increased at a similar rate with both lung volumes (5.3 to 6.7 kPa in 3 minutes) but Pa_{CO_2} at 30% Sa_{O_2} was 0.4 kPa higher with the larger FRC because of the longer time taken to reach this value of saturation. Cerebral blood flow (CBF) increased from 46 (ml/minute)/100 g to 183 (ml/minute)/100 g and this increased brain oxygen tension (Pb_{O_2}) to maximum values of 5.5 and 5.7 kPa at 1.2 minutes and 2.4 minutes with the 1.5 and 3.0 litre FRC respectively (Figs 1 and 2).

Pb_{O_2} did not decrease to the initial values until 2.4 minutes with the 1.5-litre FRC and 3.8 minutes with the 3.0 litre FRC despite the decrease in Sa_{O_2}. Cardiac output also increased (to about 13.5 litres/minute when the Sa_{O_2} had decreased to 30%) but the increase was relatively small in the early stages of desaturation so that mixed venous P_{O_2} started to decrease as soon as Sa_{O_2} decreased below 90% (Fig. 2).

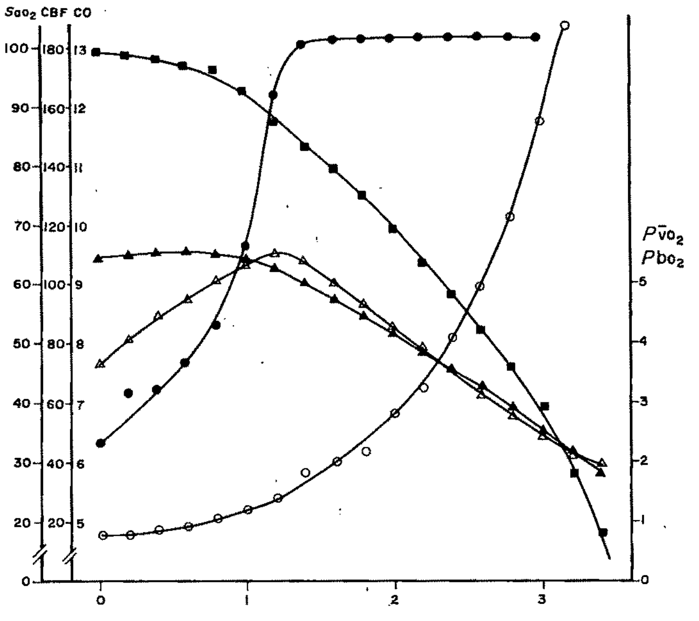

Fig. 2. Changes in arterial oxygen saturation ($S\mathrm{ao}_2$), cerebral blood flow (CBF), cardiac output (CO), brain $P\mathrm{o}_2$ ($P\mathrm{bo}_2$) and mixed venous $P\mathrm{o}_2$ ($P\bar{\mathrm{v}}\mathrm{o}_2$) after disconnexion from the ventilator with FRC of 1.5 litre. $P\mathrm{aco}_2$ increased to 6.7 kPa at 3 minutes. -○-, CO litres/minute; -●-, CBF ml/minute/100 g tissue; -■-, $S\mathrm{ao}_2$ %; -▲-, $P\bar{\mathrm{v}}\mathrm{o}_2$ kPa; -△-, $P\mathrm{bo}_2$ kPa.

Oxygen supply failure and continued ventilation with a hypoxic gas mixture in a non-rebreathing system

$P\mathrm{ao}_2$ and $S\mathrm{ao}_2$ decreased rapidly and 90% $S\mathrm{ao}_2$ was reached within 28 seconds with the 3.0 litre FRC. The 1.5 litre FRC simulation resulted in large oscillations of breath-by-breath changes in $P\mathrm{AO}_2$, but calculations which assumed an exponential washout confirmed that the desaturation occurred even more rapidly. $S\mathrm{ao}_2$ had decreased to less than 45% one minute later, irrespective of the value of FRC (Fig. 3).

Disconnexion of breathing system from fresh gas supply

Two-litre Mapleson D (Bain) system, FRC 1.5 litres. $S\mathrm{ao}_2$ decreased to 90% in 2.5 minutes and in succeeding minutes it fell to 65% and 33% (Fig. 4). $P\mathrm{aco}_2$ increased from 5.3 kPa to 6.9 kPa at 3 minutes; $P\mathrm{bo}_2$ increased from 3.6 kPa to a maximum of 5.7 kPa at 2.6 minutes and remained above baseline values until 3.6 minutes after the disconnexion, even though $S\mathrm{ao}_2$ was 57% at this time.

Five-litre Circle CO_2 absorption system, FRC 1.5 litres. $S\mathrm{ao}_2$ reached 90% in 4.6 minutes and in subsequent minutes it decreased to 75% and 53% (Fig. 4). $P\mathrm{aco}_2$ was unchanged but cerebral blood flow increased as $S\mathrm{ao}_2$ fell, and $P\mathrm{bo}_2$ increased from 3.6 kPa to a maximum of 4.5 kPa at 5 minutes and remained above baseline values until 6 minutes after the disconnexion.

Five-litre Circle CO_2 absorption system, FRC 3.0 litres. $S\mathrm{ao}_2$ reached 90% in 5.4 minutes and in subsequent minutes it decreased to 77% and 58% (Fig. 4). $P\mathrm{bo}_2$ reached a maximum of 4.6 kPa at 6 minutes and remained

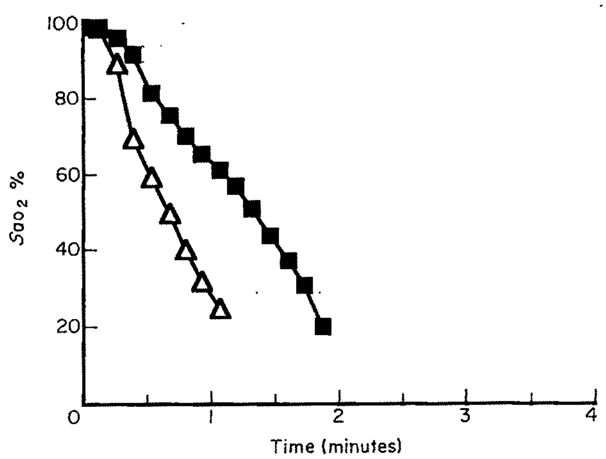

Fig. 3. Changes in arterial oxygen saturation ($S\mathrm{ao}_2$) after oxygen supply failure with continued ventilation with hypoxic gas mixture in a nonrebreathing system (FRC 1.5 litres, -△-; and 3.0 litres, -■-).

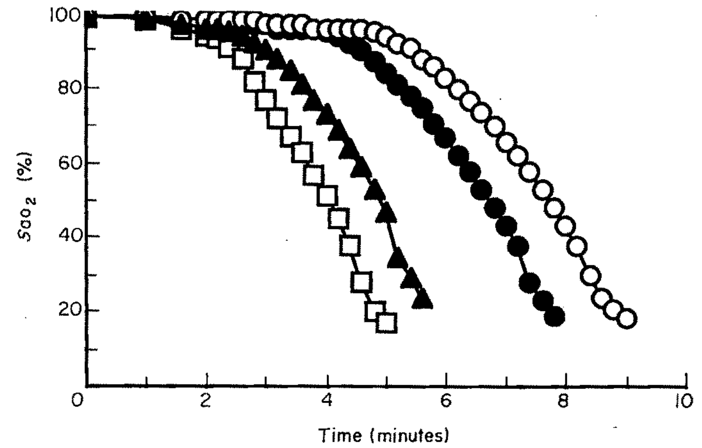

Fig. 4. Changes in arterial oxygen saturation (Sa_{O_2}) resulting from simulated disconnexion of the fresh gas flow into a Mapleson D system (FRC 1.5 litres, system volume 2 litres, –□–) and circle CO_2 absorption system of 5 litres volume with FRC of 1.5 litres (–●–) and 3.0 litres (–○–). The FRC 1.5 litres, system volume 5 litres (–▲–) simulation was also performed with an increased oxygen consumption produced by increasing the patient temperature to 40°C.

above baseline for 7 minutes after disconnexion.

Five-litre Circle CO_2 absorption system, FRC 1.5 litre. Body temperature 40°C. Sa_{O_2} of 90% was reached within 3 minutes and in subsequent minutes Sa_{O_2} decreased to 73% and 47% (Fig. 4). Brain P_{O_2} reached a maximum of 5.6 kPa 3.4 minutes after disconnexion and remained above baseline values for 4.6 minutes.

Discussion

The MacPuf computer model of the respiratory system was designed as a teaching aid to enable students to obtain a better understanding of respiratory physiology. The model incorporates the available physiological data on the response of the cardiovascular and respiratory systems to various stimuli and also enables the operator to examine the effects of alterations in respiratory control mechanisms, lung mechanics and gas exchange. We used the basic 70 kg human characteristics for the purposes of this study, and assumed that the lungs were ventilated mechanically with an inspired oxygen concentration of 30%, a tidal volume of 500 ml and a frequency of 12 breaths/minute, with an oxygen consumption of 250 ml/minute and carbon dioxide production of 200 ml/minute (respiratory exchange ratio 0.8). This yielded values for $P_{A_{O_2}}$, Pa_{O_2}, Pa_{CO_2} of 22.4, 20.4 and 5.3 kPa respectively, with a venous admixture of 1.4%. Deadspace was 97 ml with the 1.5 litre FRC and 142 ml with the 3.0 litre FRC; deadspace : tidal volume ratios were 0.19 and 0.28.

The main object was to study the pattern of arterial desaturation that resulted from various causes. The rate of desaturation after induction of apnoea by disconnexion of the patient from the breathing system depended on the volume of oxygen present in the FRC, as would be expected. This was 283 ml (STPD) with the 1.5 litre FRC and 558 ml with the 3.0 litre FRC. Consequently, it took twice as long for Sa_{O_2} to decrease to 90% with the 3.0 litre FRC as with the 1.5 litre FRC. However, the rate of decrease in subsequent minutes appeared to be affected little by the FRC and it is of interest that the Sa_{O_2} could have fallen to 65% before the pulse oximeter alarmed at a reading of 90%.

The rate of desaturation was greatest when ventilation was continued with a hypoxic gas mixture in a non-rebreathing system. The rate of washout of a lung is related to the ratio of alveolar ventilation to lung volume; thus, the rate of fall of Sa_{O_2} with a 1.5-litre FRC was approximately double that of the 3.0-litre FRC (the model assumes a larger dead space with the 3.0-litre FRC so that alveolar ventilation is 4.3 litres/minute instead of 4.8 litres/minute with the 1.5-litre FRC). The rapid decrease of Sa_{O_2} observed in this situation demonstrates that the patient could have suffered severe hypoxic damage before a pulse oximeter alarmed. The effect of a sudden switch to a hypoxic gas mixture in a partial rebreathing system could not be simulated on MacPuf. However, it would be predicted that the presence of an extra volume between the machine and patient would slow the rate of decrease of Sa_{O_2}.

Disconnexion of the fresh gas input in the presence of continued ventilation naturally resulted in a much later onset of desaturation because of the large stores of oxygen within the breathing system. Thus, an Sa_{O_2} of 90% was reached in 2.5 minutes with a 2-litre breathing system volume and in 4.6 minutes with a 5-litre system volume and 1.5-litre FRC, whilst with a 3.0-litre FRC and a 5-litre system volume it took 5.4 minutes to reach 90% Sa_{O_2}. However, 90% Sa_{O_2} was reached in 3 minutes instead of 4.6 minutes with an FRC of 1.5 litres and a 5-litre system volume when oxygen consumption was increased from 250 to 270 ml/minute by increasing the patient's temperature to 40°C.

The delay in the onset of desaturation that results from the use of high lung and breathing system volumes is regarded as an additional safety factor by proponents of circle CO_2 absorption systems. However, it is the rate of fall of desaturation *after* the alarm has sounded which will determine the extent of hypoxic damage if reliance is placed on a pulse oximeter. The simulations of continued ventilation with a hypoxic gas mixture in a non-rebreathing system showed that the decrease in Sa_{O_2} in the first minute after reaching 90% Sa_{O_2} is very rapid and Sa_{O_2} may easily

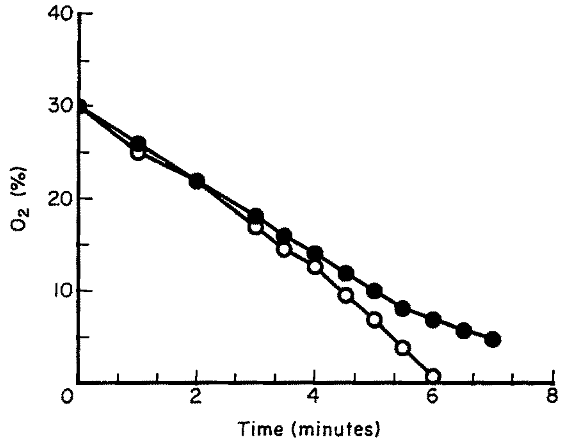

Fig. 5. Comparison of calculated (–○–) decrease in bag oxygen concentration with MacPuf simulation (–●–) of disconnexion of fresh gas supply into a 5-litre circle CO_2 absorption system with FRC of 1.5 litres and oxygen consumption of 250 ml/minute. Initial $F\text{IO}_2$ 0.3. The calculated rate of decrease of oxygen concentration is faster than the MacPuf simulation because the former does not take into account the buffering effect produced by the decrease in blood and tissue oxygen stores.

reach 30–40% within one minute. However, it is of interest that with the other simulations of disconnexion from the ventilator or disconnexion of the fresh gas supply, $S\text{aO}_2$ may also fall to 65–70% in one minute after reaching 90%, and at the end of 2 minutes $S\text{aO}_2$ varies between 30 and 60%. The cause of this rapid desaturation is the steep slope of the oxygen dissociation curve below 90% $S\text{aO}_2$. Inspection of the $P\text{aO}_2$ values in Figure 1 shows that the decrease in $P\text{aO}_2$ is approximately linear down to about 95% $S\text{aO}_2$. This would be predicted from the steady oxygen consumption associated with a constant cardiac output and normal mixed venous $P\text{O}_2$. However, there is a decrease in arterial oxygen content followed by a decrease in tissue oxygen stores when the arterial blood begins to desaturate. Consequently, there is a temporary reduction in the volume of oxygen transferred from the alveoli to the blood, even though the volume consumed by the tissues is unchanged. This tends to decrease the rate of decrease of alveolar and arterial $P\text{O}_2$ (Fig. 5). Thus, the tissues effectively maintain their oxygen supply by depleting the oxygen stores in the blood and extracellular fluid. Anaerobic metabolism occurs at lower levels of $S\text{aO}_2$, thus decreasing oxygen consumption and the rate of fall of $S\text{aO}_2$ further.

One of the other interesting changes demonstrated in these simulations is the protection provided by the increase in cerebral blood flow. The increase in cerebral blood flow results from the decrease in $P\text{aO}_2$ (flow is doubled when $P\text{aO}_2$ decreases to 8 kPa and $S\text{aO}_2$ to 90%) and is augmented further by a concomitant increase in $P\text{aCO}_2$ (cerebral blood flow is more than trebled at the same $P\text{aO}_2$ when the $P\text{aCO}_2$ is increased by 1 kPa). The increase in flow results in an increase in $P\text{bO}_2$ which reaches a maximum and then declines. In all the simulations, $P\text{bO}_2$ did not decrease below normal until the $S\text{aO}_2$ had decreased to less than 60%. Thus the organ most sensitive to oxygen lack is protected when normal physiological mechanisms are active. However, in patients with diseased cerebral vessels this mechanism may be less effective and cerebral damage may occur at higher values of $S\text{aO}_2$.

The MacPuf model uses algorithms based on physiological data. Clearly, there is a wide variation in the manner in which individual patients respond to the type of perturbation simulated in these studies. The model also tends to become unstable when very rapid changes are being induced. Despite these limitations it is believed that useful information is provided.

Conclusions

The time delay between the onset of the malfunction and the decrease in $S\text{aO}_2$ depends on the initial volume of oxygen in the lungs and breathing system, on the oxygen consumption and on the cause of the oxygen supply failure. The delay is shortest when there is continued ventilation with a hypoxic gas mixture, intermediate when disconnexion from the breathing system results in apnoea and longest when there is a disconnexion of the fresh gas supply into a circle CO_2 absorption system.

$S\text{aO}_2$ may have reached low levels by the time an alarm set at 90% $S\text{aO}_2$ has been activated if it is assumed that there is a one-minute delay between a change in alveolar gas composition and registration of the resulting change in $S\text{aO}_2$ on a pulse oximeter display. Damage from hypoxaemia may be averted if the patient is immediately disconnected from the breathing system and hyperventilated with air or oxygen. Severe hypoxic damage may ensue if the anaesthetist does not respond immediately, or if the pulse oximeter response time is increased to 2–3 minutes by vasoconstriction or venous congestion.[5] It is particularly important to remember that it takes a finite time to wash out the breathing system and the lungs even if the oxygen supply is restored immediately, and this delay may be increased greatly if the breathing system has a large volume or the fresh gas flow rate is low.

Our results confirm that the pulse oximeter should be regarded as the final link in the chain of oxygen supply monitors. Early warning of oxygen supply failure must be provided by devices which can detect, firstly, a decrease in oxygen supply pressure or concentration and, secondly, a disconnexion of the breathing system either from the fresh gas supply or from the patient.

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Lytic cocktail in children

Rectal versus intramuscular administration

M. LAUB, P. SJØGREN, R. HOLM-KNUDSEN, H. FLACHS AND E. CHRISTIANSEN

Summary

The efficacy of the lytic cocktail (1 ml contains pethidine 28 mg, promethazine 7 mg, chlorpromazine 7 mg) administered intramuscularly or rectally as premedication was studied in 51 children aged 1–12 years who had minor elective otological surgery. One group received 0.05 ml/kg intramuscularly (maximum dose 2.0 ml) and the other 0.07 ml/kg per rectum (maximum dose 2.8 ml). Most were satisfactorily sedated before operation, but after operation the rectally premedicated children were less sedated, which was in agreement with lower plasma pethidine concentrations in this group. The rectal dose should be increased if prolonged postoperative sedation is desireable.

Key words

Premedication; lytic cocktail.
Anaesthesia; paediatric.

The lytic cocktail was introduced in 1951 and since then it has been used widely in children by intramuscular injection for premedication, to produce sedation during minor surgery, heart catheterisation and radiological investigations.[1–5] It usually contains pethidine 28 mg, promethazine 7 mg and chlorpromazine 7 mg per ml.

Its popularity as a premedicant is due to its analgesic, anxiolytic, antiemetic, antisialogue and sedative effects, which are presumed to result from a favourable interaction between the three drugs. Rectal rather than intramuscular administration is generally more acceptable to infants and children,[6,7] so we decided to compare the sedative effects and plasma concentrations of pethidine after the two forms of administration. As far as we know, this has not previously been done in children with this preparation.

Methods

The study was carried out in 60 children, 22 girls and 38 boys, aged 1–12 years scheduled for minor elective otological surgery under general anaesthesia. Those with mental disease, disturbance of the lower gastrointestinal tract, or with known allergy to the drugs were not studied. Parental consent and approval by the national health authorities and local scientific ethics committee was obtained.

The children were randomly allocated to two groups. One was premedicated with the lytic cocktail 0.05 ml/kg intramuscularly (maximum dose 2.0 ml) given in the upper part of the thigh, while the others received 0.07 ml/kg rectally (maximum 2.8 ml) using a plastic tube which was introduced approximately 5 cm. Premedication was given 30 minutes before the induction of anaesthesia.

Sedation was evaluated by means of a four-point scale: asleep; awake but calm; apprehensive; crying. This was done on arrival in the anaesthetic unit, at induction of anaesthesia, and on arrival in the operating theatre. The evaluations were performed by the same anaesthetic nurse, who was unaware of the route of administration.

The time from premedication to arrival in the operating theatre and to induction of anaesthesia were recorded, as were any side effects. Induction of anaesthesia was by inhalation of O_2/N_2O (33%/66%) and halothane 1–4% or, if the child so preferred, by intravenous injection of thiopentone 5 mg/kg. Anaesthesia was maintained with O_2/N_2O (33%/66%) and halothane 0.5–2% by facemask or tracheal tube.

Blood samples were taken for pethidine analysis in 24 children, 12 in each group, comparable in age and weight. This was done after 50 (SD 3) minutes and again after 85 (SD 3) minutes. The plasma pethidine analysis was carried out by gas chromatography–mass spectrometry. Methods for determination of the plasma concentrations of promethazine and chlorpromazine were not available.

The Mann–Whitney test was used for statistical analysis of demographic data, and the Chi-squared test for analysis of the degree of sedation and plasma pethidine concentrations. Sedation was regarded as satisfactory if the child was

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Table 1. Weights, ages, time from premedication to assessments and duration of anaesthesia. Values are expressed as mean (SD).

	Intramuscular group	Rectal group
Weight, kg	25.6 (7.2)	25.2 (6.7)
Age, years	5.9 (2.9)	5.5 (2.8)
Time in minutes from premedication to assessments		
Arrival	19 (2.8)	19 (2.7)
Induction	30 (1.4)	30 (1.5)
Recovery	69 (8.4)	74 (7.8)
Duration, minutes, of anaesthesia	28 (7.1)	27 (6.2)

Table 2. Evaluation of sedation.

	Intramuscular group ($n=25$)			Rectal group ($n=26$)		
	Arrival	Induction	Recovery	Arrival	Induction	Recovery
Asleep	3	2	17	2	1	8
Awake, but calm	20	17	7	21	22	10
Apprehensive	2	6	0	2	1	2
Crying	0	0	1	1	2	6

asleep or awake but calm, and unsatisfactory if apprehensive or crying.

$p < 0.05$ was considered as statistically significant.

Results

Nine of the 60 children were excluded because of errors in the procedure. The sedation scores for two children from each group were not recorded; two from the intramuscular group and one from the rectal group did not receive any premedication, while one child from each group was anaesthetised more than 30 minutes after premedication. There were thus 25 children in the intramuscular group and 26 in the rectal. They were comparable with regard to age, weight, time from premedication to assessment and duration of anaesthesia (Table 1).

The results of the assessment of sedation at the various times are shown in Table 2. There were no statistical differences between the groups on arrival in the anaesthetic room or at the time of induction of anaesthesia. Sedation was satisfactory in the majority of children. Eight children in the rectal group were apprehensive or crying after operation compared to only one in the intramuscular group ($p < 0.05$). A few children in the rectal group complained of gastric distension or need for defecation, but this did not result in discharge of the premedication. Six children in the rectal group as opposed to none in the intramuscular were nauseated after operation.

Table 3. Plasma pethidine levels (nmol/litre) in the two groups 50 and 85 minutes after premedication. The pethidine levels in the rectal group are statistically significantly lower after both 50 minutes ($p=0.001$) and 85 minutes ($p=0.002$).

	Intramuscular group (minutes)		Rectal group (minutes)	
	50	85	50	85
	1502	1460	253	283
	1823	1164	1081	983
	1291	1147	407	407
	1216	1060	763	738
	1567	1426	500	445
	1281	1295	515	459
	1297	1177	539	505
	1596	1343	935	759
	1875	1625	1186	903
	784	999	713	684
	507	555	858	731
	990	922	383	322
Mean	1311	1181	678	602
SD	405	283	293	229

The results of the plasma pethidine analysis appear in Table 3. Plasma concentrations are lower in the rectal group both after 50 and 85 minutes and this difference is statistically significant ($p < 0.05$).

Discussion

This study shows that the lytic cocktail produces good pre-operative sedation in children given either rectally or intramuscularly. The advantage of rectal administration is avoidance of a painful injection, but these children were less sedated after operation and appeared to be suffering more pain than the intramuscular group. The rectal dose was chosen arbitrarily although based on the assumption that absorption from the rectum is slower than from muscle. A higher rectal dose could be expected to give longer postoperative sedation, which should be investigated. The results of the plasma pethidine analyses suggest that it will be justifiable to increase the rectal dose to 0.1 ml/kg, double the intramuscular dose.

It is not certain that the three drugs of the lytic cocktail are absorbed from the rectum in the same proportion as from muscle. The fact that more children in the rectal group, even though not statistically significant, suffered from nausea indicates that absorption of promethazine is poor. We could not study this, but until more is known, more prolonged postoperative sedation and, perhaps, a better antiemetic effect could be obtained by an extra peroperative small intramuscular dose (0.025 ml/kg) of lytic cocktail.[8]

In conclusion, rectally administered lytic cocktail was found suitable for premedication in children, but postoperative sedation was less pronounced than when it was given intramuscularly.

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The Bain, ADE, and Enclosed Magill breathing systems

A comparative study during controlled ventilation

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Summary

The Enclosed Magill, Humphrey ADE and the Bain breathing systems are all used for controlled ventilation of the lungs. This study compares the three systems in vitro with a lung model and in clinical practice. No difference was observed, with ventilatory variables commonly used in clinical practice, between the Bain and the ADE, while significantly lower end-tidal carbon dioxide values were observed with the Enclosed Magill (about 7%). Lower fresh gas flows can be used under these circumstances to maintain normocapnia with the Enclosed Magill than either the Bain or the Humphrey ADE.

Key words

Equipment; breathing systems.

The Enclosed Magill (Afferent Reservoir)[1,2] and the Humphrey ADE (ADE) breathing systems[3] were introduced to anaesthetic practice in recent years. They are suitable for controlled ventilation of the lungs and, as such, are both alternatives to the Bain system. There are several studies which evaluate each of these breathing systems and demonstrate them to be similar in efficacy to the Bain. The Enclosed Magill (afferent reservoir) at set ventilation and fresh gas flow is reported to result in a lower end-tidal carbon dioxide concentration than the Bain[2]. The ADE is also reported to produce lower values than the Bain but in the latter case the difference is small.[4]

This study was undertaken to compare all three breathing systems directly under similar circumstances to determine the difference between them.

Method

The three breathing systems tested were the Bain, ADE and the Enclosed Magill. The latter system was the basic design[5] without preferential flow[2] or flow restrictors, both of which almost certainly improve performance (see Discussion).

The study consisted of three parts. An *in vitro* comparison of the three systems, a clinical study in anaesthetised patients before surgery, and a clinical study during surgery.

Laboratory study

Each system was evaluated under identical *in vitro* circumstances using a lung model. This consisted of a bag-in-bottle with the bag primed with one litre of air and connected to a spring-loaded bellows. The space between the bag and bottle was, in effect, the lung and this was connected to the breathing system with a measured length of tubing which constituted part of the deadspace, the apparatus deadspace. A known volume of carbon dioxide was introduced into the 'lung' each minute and mixed by the electric fan within the bottle. A Penlon Oxford ventilator was used to ventilate the breathing system, and total ventilation of the 'lung' was measured with a Wright electronic spirometer. The concentration of carbon dioxide was measured continuously with an in-line Hewlett Packard capnograph (Fig. 1).

Values based on clinically used ventilatory variables for a 70-kg male were chosen, with a tidal volume of 700 ml and a rate of 12/minute. Fresh gas flow was set at 5.0 litres/minute. Each system (Fig. 2) was evaluated at the same ventilation rate and tidal volume. The apparatus deadspace was set at 0.4 × tidal volume and the carbon dioxide production set at 160, 180 and 200 ml/minute. The study was repeated with the carbon dioxide production maintained at 180 ml/minute and the apparatus deadspace set at 0.3, 0.4 and 0.5 of the tidal volume. The apparatus deadspace was determined by simple water displacement which is readily reproducible. However it is not the same as 'physiological' deadspace which may also incorporate effective deadspace within the lung. Fifteen minutes were allowed for equilibration at each measurement point. The time constant for CO_2 washout with a 'lung' volume of 4 litres and alveolar ventilation of the order of 4.8 litres per

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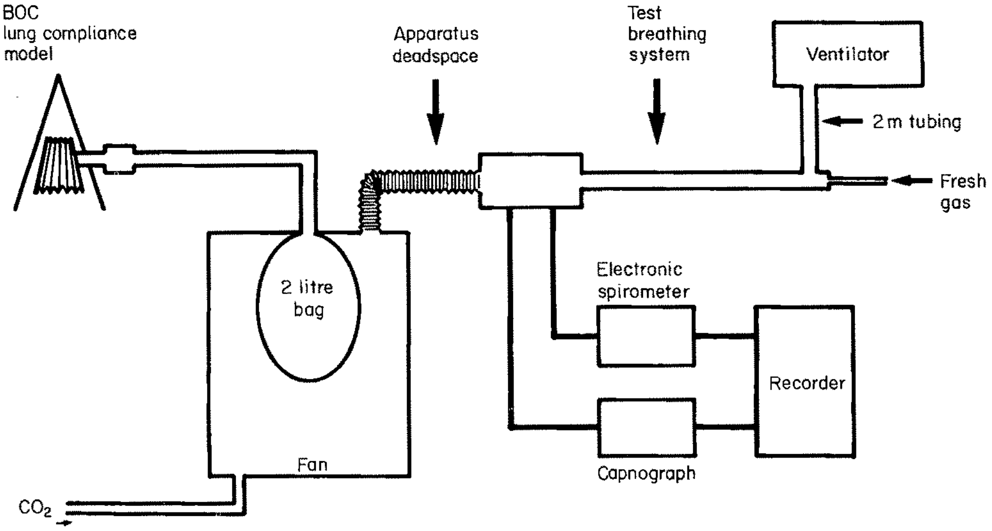

Fig. 1. Lung model used to compare the breathing systems. The lung is the part of the bag-in-bottle between the bag and the bottle. Carbon dioxide can be entrained into the bottle and the apparatus deadspace is also easily altered. The test breathing system has an independent fresh gas supply from the ventilator and the two are separated by 2 m of tubing so that no mixing occurs.

minute should be about 50 seconds. Each part of the study was repeated three times.

Clinical study before surgery

The second part of the study involved three groups of patients, ASA 1, who were to have routine dental anaesthesia. A pair of breathing systems was compared in each group and used consecutively in each patient. One system was used first in half of the group and the second in the other half by random allocation so that the effects of time on the equilibration of carbon dioxide did not predominate with either system. The ADE was compared with the Bain in group 1 and the ADE with the Enclosed Magill in group 2, and in group 3 the Bain with the Enclosed Magill.

Each patient was premedicated with papaveretum 0.4 mg/kg (with scopolamine), induced with thiopentone 4 mg/kg, and following vecuronium 0.1 mg/kg, nasotracheal intubation was performed. The patient was connected to the breathing system by a catheter mount of known volume, to the end of which the measuring apparatus was attached. Anaesthesia was maintained with oxygen, nitrous oxide and enflurane 1%. The patient's lungs were ventilated with a Manley Pulmovent, with a total ventilation of 120 (ml/kg)/minute. Fresh gas flow, from an independent source, was set at 70 (ml/kg)/minute. Tidal volume was approximately 10 (ml/kg)/minute with a resultant frequency of 12 per minute. A period of 10 minutes was allowed for stabilisation of end-tidal carbon dioxide which was measured. The breathing system was changed and a further 10 minutes allowed during which time the end-tidal CO_2 was again measured. The carbon dioxide concentration was continuously recorded using a Hewlett Packard capnograph and the end-tidal value taken from the recorded waveform. This was measured at the end of the catheter mount as was the ventilation. The total ventilation was confirmed using a Wright's Electronic Spirometer.

Clinical study during operation

The third part of the study was performed at another hospital; the systems were tested during operation under normal clinical conditions. Three groups of patients for procedures anticipated to last longer than 2 hours, ASA 1–3, gave consent to be studied. Two breathing systems were tested in each group. Premedication and induction were as before, except that there was a reduction in drug dosage in the elderly and in this part of the study orotra-

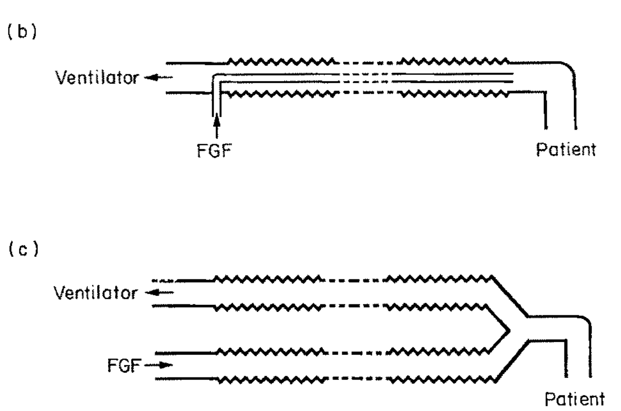

Fig. 2. Breathing systems under test. (a) the Enclosed Magill, (b) the Bain system, (c) the ADE in 'E' mode.

Table 1. *In vitro* comparison of the three systems at three different CO_2 production rates. The ventilatory settings were: tidal volume 700 ml, rate 12/minute, V_D/V_T ratio 0.4. Fresh gas flow (V_f) 5.0 litres/minute.

CO_2 production ml/minute	Mean end-tidal CO_2 (kPa) $n=3$ (SD) ADE	Bain	Enclosed Magill
160	5.3 (0.06)	5.2 (0.08)	4.6 (0.1)
180	5.6 (0.05)	5.7 (0.1)	5.0 (0.06)
200	6.3 (0.06)	6.5 (0.1)	5.5 (0.1)

Table 2. *In vitro* comparison of the three systems at three different V_D/V_T ratios, 0.3, 0.4, 0.5. The ventilatory settings were: tidal volume 700 ml, rate 12/minute, carbon dioxide production 180 ml/minute. Fresh gas flow (V_f) 5.0 litre/minute.

Dead space V_D/V_T ratio	Mean end-tidal CO_2 (kPa) $n=3$ (SD) ADE	Bain	Enclosed Magill
0.3	5.4 (0.1)	5.4 (0.06)	4.8 (0.1)
0.4	5.6 (0.06)	5.7 (0.05)	5.0 (0.08)
0.5	6.4 (0.06)	6.1 (0.11)	5.4 (0.12)

cheal intubation was used. Total ventilation of 130 (ml/kg)/minute was instituted by supplying the Manley Pulmovent ventilator with the requisite minute volume from an independent gas source. Tidal volume approximated to 10 ml/kg. Fresh gas flow was set at 70 (ml/kg)/minute. The first system was used for 40 minutes and the end-tidal carbon dioxide measured. Then the second system was substituted and the end-tidal carbon dioxide measured for the next 30 minutes. A capnograph (Datex Normocap) aspirating gas at 150 ml/minute from a sample port at the end of the tracheal tube, was used to measure carbon dioxide concentrations, and the peak concentration was read from the display. A Wright spirometer was used to measure ventilation.

Wilcoxon matched-pairs, signed rank test was used for statistical analysis. Each patient gave informed consent and the study was approved by the Ethics committees of Westminster Hospital and St. Peter's Group of Hospitals, Covent Garden, WC2 respectively.

Results

Laboratory study

The *in vitro* results with a lung model show that (Table 1) the end-tidal carbon dioxide was lower at each setting with the Enclosed Magill. There was little difference between the Bain and the ADE.

The deadspace in the tubing was set at 0.3, 0.4 and 0.5 of the tidal volume and CO_2 production of 180 ml/minute and again the end-tidal carbon dioxide was lower with the Enclosed Magill and there was little difference between the Bain and the ADE.

Clinical study before surgery

There were relatively short periods of stabilisation and no operative activity at the time of the measurements. The results are given in Table 3. The mean difference between the Bain and Enclosed Magill was 0.34 kPa (95% confidence limits 0.32–0.35) and between the Enclosed Magill and ADE the mean difference was 0.38 kPa (95% confidence limits 0.36–0.40). There was significant difference between the Bain and the Enclosed Magill (two tailed $p = 0.0034$) and the ADE and the Enclosed Magill (two tailed $p = 0.0024$). There was no significant difference between the Bain and the ADE.

Clinical study during operation

The equilibration period was longer in the third part of the study and the results are in Table 4. The mean difference between the Bain and Enclosed Magill was 0.37 kPa (95% confidence limits 0.30–0.44) and between the Enclosed Magill and ADE the mean difference was 0.43 kPa (95% confidence limits 0.38–0.48).

There was significant difference between the Bain and the Enclosed Magill (two tailed $p = 0.0098$) and the ADE and the Enclosed Magill (two tailed $p = 0.0039$). There was no significant difference between the Bain and the ADE.

Table 3. Clinical study before surgery. The end-tidal carbon dioxide values (kPa) with each pair of systems with a fresh gas flow of 70 (ml/kg)/minute and ventilation of 120 (ml/kg)/minute. Age range 20–44 years. Short (10 minutes) equilibration time.

	Weight (kg)	Bain	ADE	Weight (kg)	Bain	EM	Weight (kg)	EM	ADE
	59	5.3	5.6	52	4.3	4.5	65	5.6	6.0
	60	5.6	5.9	57	5.2	4.7	91	4.6	5.6
	62	4.8	4.8	55	5.5	5.0	65	6.0	6.2
	51	5.2	5.3	60	5.3	4.9	50	5.5	5.7
	68	5.4	5.3	52	5.0	4.5	88	4.3	5.1
	55	5.4	5.6	60	5.9	6.0	64	6.1	6.1
	51	5.9	5.9	58	5.1	4.7	68	5.5	5.3
	54	6.6	6.6	53	5.8	5.5	47	5.3	5.9
	62	5.5	5.6	76	5.8	5.1	58	5.7	5.7
	54	6.4	6.2	63	4.8	4.5	67	5.2	5.7
	50	5.5	5.4	74	6.4	6.4	75	4.8	5.3
	66	5.5	5.6	62	6.3	6.1	58	5.2	5.7
	72	5.2	5.2	80	5.9	5.3	56	4.8	4.9
	52	5.5	5.4	79	5.3	5.3	57	5.4	5.8
Mean (SD)	—	5.6 (0.5)	5.6 (0.5)	—	5.5 (0.6)	5.2 (0.6)	—	5.3 (0.5)	5.7 (0.4)

Table 4. Clinical study during operation. End-tidal carbon dioxide values after ventilation at fresh gas flow of 70 (ml/kg)/minute and ventilation at 130 (ml/kg)/minute. Long equilibration period (40 minutes)

	Weight (kg)	Age	Bain	ADE	Weight (kg)	Age	Bain	EM	Weight (kg)	Age	EM	ADE
	60	38	5.0	4.6	64	57	4.9	4.0	76	84	4.8	4.6
	55	20	5.0	4.8	85	38	4.2	4.4	73	76	3.8	4.2
	80	62	5.2	5.4	63	68	4.4	4.3	60	72	4.2	4.7
	92	59	3.8	3.6	57	56	4.5	4.3	81	80	4.6	5.2
	75	75	4.0	4.0	87	55	4.5	4.0	76	62	4.2	5.1
	75	70	5.3	5.0	65	75	4.1	3.5	80	31	4.4	4.9
	67	57	5.0	5.0	75	66	5.6	4.8	70	76	3.6	3.6
	88	66	4.0	4.3	51	67	4.5	4.1	68	63	4.4	4.8
	82	41	4.8	5.0	74	65	4.0	3.6	61	38	5.1	5.6
	76	75	4.3	4.4	83	45	4.6	4.2	62	60	4.4	4.7
	45	28	4.7	4.0								
	70	31	5.3	5.0								
Mean (SD)	—	—	4.7 (0.53)	4.59 (0.53)	—	—	4.5 (0.45)	4.12 (0.38)	—	—	4.3 (0.43)	4.74 (0.55)

Discussion

There was a small but significant difference between the Bain and the Enclosed Magill and the ADE and the Enclosed Magill in all three parts of the study. There was no difference between the ADE and the Bain.

The bench testing allowed all three systems to be compared directly under identical conditions. The problems of patient variability are avoided and full equilibration occurred in the system; both of these factors complicate clinical studies. The use of a lung model to produce *in vitro* results should complement clinical findings and is a reasonable method to start the assessment of a physical system such as a breathing system. The model demonstrated the same similarities and differences as the clinical studies.

Both clinical studies elicited a difference between the Enclosed Magill and the other two systems. This corresponds with the findings when the Enclosed Afferent Reservoir systems[2] were compared with the Bain. It should be emphasised that the Enclosed Magill system used in the study reported here lacked any form of preferential flow device. The presence of either a preferential flow device system or an expiratory limb resistance tends to prevent premature valve opening and this enhances the performance of the system by a reduction of the elimination of deadspace gas. The use of such a device would almost certainly increase the efficiency of the system.

Both clinical studies failed to show a difference between the ADE and the Bain. Humphrey did report a significant difference between the two systems but commented that the difference was small.[4] However Shah has demonstrated convincingly that the Bain has lower fresh gas flow 'requirements' to achieve normocapnia than the ADE, when ideal ventilatory variables are used.[6] This is in contrast to the studies described here where the ventilatory variables were chosen because they correspond to the manner in which the systems are commonly used in practice. These are not necessarily those which produce the most efficient use of the systems. It is well established that the performance of breathing systems can be altered by the pattern of ventilation.[4,7–11] Furthermore the common choice of total ventilation in the order of 120–150 (ml/kg)/minute ensures that the resultant end-tidal carbon dioxide value is determined by the interaction of the effects of both the ventilation and the fresh gas flow. This may reduce both efficiency and predictability of the breathing systems. It is inevitable as a consequence of the influence of all these factors that there will be marked differences between studies based on commonly used variables and those which seek optimal ventilatory patterns and rates before the assessment of fresh gas flows.[6] It is accepted that considerably lower fresh gas flows could be employed if optimal ventilation was sought but the purpose of this study was to evaluate the systems in the circumstances in which they are normally used.

The two clinical parts of our study have given the same results, in terms of similarities and differences, between the breathing systems. However, the absolute values in each part of the study vary considerably and it should be emphasised that the two clinical parts of the study are not directly comparable because there were major differences in the methods. The hospitals, intubation techniques, ventilatory volumes and measurement equipment were all different. Tables 3 and 4 show that one population was young and fit, while the other was older, less fit but probably more representative of normal anaesthetic practice. Furthermore the periods of time allowed for equilibration were different. The short period of equilibration was a compromise because use of the period before operation allowed greater control of the study than under normal clinical circumstances, but restricted the time available. It is accepted that this period of time is inadequate for full equilibration;[13] all three systems were treated in the same manner and the patients served as their own controls which allowed comparison. The third part of the study allowed considerably longer equilibration periods but there was less control of the circumstances during measurement. It is of interest that in this part of the study the values of end-tidal carbon dioxide at 20 and 30 minutes were almost identical.

Both studies demonstrated the similarity between the Bain and the ADE and the difference from the Enclosed Magill, despite the differences in method, and these results agreed with the findings from the lung model. The range and difference in values in both studies serve to emphasise the effects of the method on the 'predictability' of the end-tidal carbon dioxide when these systems are used and reinforces the necessity of monitoring end-tidal carbon dioxide during controlled ventilation.

We have shown that, using similar ventilatory variables and at a set fresh gas flow of 70 (ml/kg)/minute the Enclosed Magill produces lower end-tidal carbon dioxide values than either the Bain or ADE, both of which perform in a similar manner. All three systems are suitable for controlled ventilation and, in clinical terms, are of similar efficacy.

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Anaesthesia, 1990, Volume 45, pages 118–119

The chronotropic effect of acetylcholine in the presence of vecuronium and atracurium

A study in the isolated perfused rabbit heart

D. J. BELLIS, S. DAY AND P. K. BARNES

Summary

The bradycardia produced by 1 μg acetylcholine in the isolated perfused rabbit heart, in the presence of vecuronium and atracurium, was studied and compared with control. Vecuronium at a concentration of 2.5 μg/litre and atracurium 6 μg/litre did not enhance the negative chronotropic effect of acetylcholine. Atracurium produced a statistically significant inhibition of the negative chronotropic effect of acetylcholine.

Key words

Neuromuscular relaxants; atracurium, vecuronium.
Heart; arrhythmia, bradycardia.

Vecuronium bromide and atracurium dibesylate are non-depolarising neuromuscular blocking agents without cardiovascular effects in anaesthetised man.[1,2] However, several case reports have described severe bradyarrhythmias, in some cases leading to sinus arrest.[3-5] Higgins and Thorp[6] postulated that vecuronium might act to make some individuals more susceptible to vagal stimulation. This experiment was designed to test the hypothesis that vecuronium and atracurium sensitise the heart to the effects of acetylcholine.

Method

Hearts of New Zealand white rabbits were isolated and perfused according to the Langendorff technique, and a constant infusion rate of oxygenated Ringer–Locke solution was established into the aorta to perfuse the coronary vasculature. The perfusate was maintained at a temperature of 37°C and at a pH of 7.0. A Walton Brodie strain gauge was sewn on to the left ventricle, and spontaneous ventricular contractions were amplified and recorded (Carrier pre-amplifier 350-110; Brush Clevite 220).

The heart was perfused with Ringer–Locke for a period of 20 minutes to achieve a steady state and the rate of cardiac contraction stabilised within 2–3 minutes. A control injection of a bolus of 1 μg acetylcholine in 0.1 ml was made into the perfusate, close to the heart. This produced a bradycardia. The perfusion was continued for 10 minutes after the control injection and the heart was then perfused with Ringer–Locke solution that contained vecuronium 2.5 μg/litre or atracurium 6 μg/litre for 20 minutes. A further injection of 1 μg acetylcholine was then administered and the bradycardia recorded. Perfusion was started with Ringer–Locke solution for 10 minutes in order to wash out the neuromuscular blocking agent. The experimental protocol was then repeated substituting the second neuromuscular blocking agent. The order of perfusion with vecuronium and atracurium was random.

At the end of the experiment 1 μg acetylcholine was injected to confirm the validity of the preparation.

Results

The injection of 1 μg acetylcholine produced a bradycardia. The response of an individual heart to acetylcholine was consistent, but there was considerable difference in the bradycardia produced by 1 μg acetylcholine between hearts. The response to the 1-μg acetylcholine injection in 19 hearts before and after perfusion with vecuronium is shown in Figure 1, and with atracurium in Figure 2.

The data were subjected to nonparametric statistical analysis (Wilcoxon Matched Pairs Signed Rank test). There was no statistically significant difference in the bradycardia due to acetylcholine during perfusion with Ringer–Locke that contained vecuronium compared with control. There was, however, a statistically significant inhibition of the bradycardia in the presence of atracurium (p, two tailed, = 0.0156).

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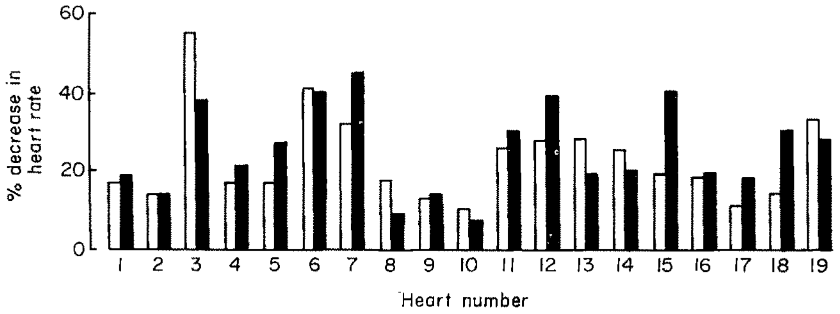

Fig. 1. The effect of 1 μg acetylcholine on heart rate. Open columns, control; filled columns, in the presence of vecuronium.

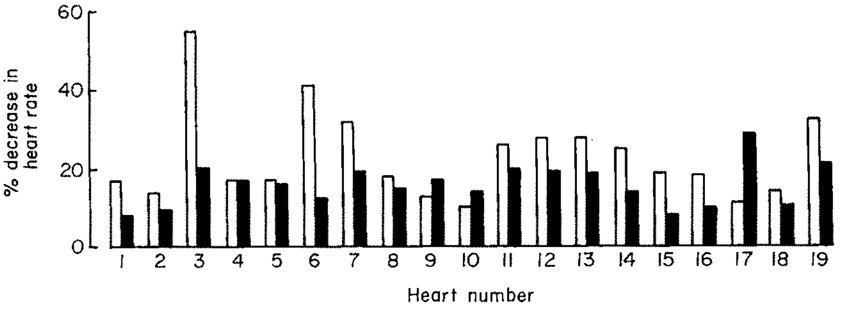

Fig. 2. The effect of 1 μg acetylcholine on heart rate. Open columns, control; filled columns, in the presence of atracurium.

Discussion

This preparation was used previously to examine cholinergic mechanisms.[7,8] The variation in bradycardia produced by 1 μg acetylcholine in different hearts and the consistent bradycardia in individual hearts was also noted.[7] The results in this experiment were only considered in hearts where bradycardias produced by control injections of 1 μg acetylcholine at the beginning and end of the experiment were within 10%. The concentration of atracurium in the perfusate was equal to the peak plasma levels after a bolus of 0.3 mg/kg in man.[9] The concentration of vecuronium was calculated on the basis that 0.6 mg/kg atracurium and 0.1 mg/kg vecuronium were equipotent. The results reported show that vecuronium does not produce vagal blockade in the dose used in this preparation, and also that vecuronium does not induce increased sensitivity to injected acetylcholine.

Atracurium in addition does not sensitise the isolated rabbit heart to the effects of injected acetylcholine. The statistically significant decrease in the bradycardia to acetylcholine is not interpreted as evidence of vagal blockade. Atracurium has been shown to produce vagal blockade in anaesthetised rhesus monkeys at 16 times the full neuromuscular paralysing dose.[10] However, the results in respect of this experiment are not considered conclusive. It is possible that higher doses in this preparation would produce vagal blockade. On the basis of our results there is no evidence to support the hypothesis that vecuronium or atracurium sensitise the isolated rabbit heart to the effects of injected acetylcholine. Extrapolation to man is hazardous, but we conclude that an increased sensitivity to vagal stimulation is not the cause of the reported cases of bradycardia when vecuronium or atracurium are in use.

Acknowledgments

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The subdural space: the third place to go astray

F. REYNOLDS AND H. M. SPEEDY

Summary

Subdural placement of the tip of the Tuohy needle or epidural catheter may account for many unexpected complications of attempted epidural blockade, for example 'unexplained' headache, false-negative aspiration test down needle or catheter, false-negative test dose, unilateral block, delayed total spinal and neurological sequelae, as well as profound block of delayed onset that is characteristic of subdural blockade. Cases are reported in support of this hypothesis.

Key words

Anaesthetic techniques, regional; epidural.
Complications.

It is universally recognised that an epidural catheter may be misplaced in the subarachnoid space or in a vein, and both aspiration and the test dose are designed to detect these two mishaps. However, both these tests may give negative results, and yet a subarachnoid block ensue. It is not always recognised that *subdural* misplacement can explain this phenomenon. Subdural siting of an epidural cathether is believed to be rare, but is often reported.[1-6] It may occur more frequently than is commonly supposed, and may account not only for the 'false' negative tests but also for a number of other epidural anomalies, including those that are popularly attributed to epidural catheter migration.

Epidural catheters used in the UK cannot penetrate dura mater although they may puncture arachnoid.[7] However, it is clearly possible for a Tuohy needle to puncture dura but not arachnoid. Blomberg,[8] using spinaloscopy, showed that in 10 out of 15 cadavers the subdural space opened up easily on injection of fluid, in four it opened with difficulty and in one it was impossible to separate arachnoid from dura. Thus the outcome of needle penetration of the dura is determined in part by individual anatomical characteristics. There are nine possible consequences when a catheter is passed through a needle so placed.

Sequence 1. The catheter enters the epidural space: normal epidural.
Sequence 2. The catheter enters the epidural space but the arachnoid later tears: 'unexplained' headache.

Case history. In 1981, a 42-year-old multipara with twins had an epidural catheter inserted during labour at a cervical dilatation of 3 cm. The epidural space was detected using loss of resistance to saline and 3.5 cm of catheter were passed into the space with ease. She was given 6 ml 0.5% bupivacaine, which produced complete analgesia with a normal speed of onset and bilateral block to T_{10}. She had no further top-ups and was delivered in comfort 2 hours 40 minutes later. She developed a classic spinal headache with postural symptoms, slight meningism, nausea and vertigo, on the second day after delivery. The headache persisted, despite conservative measures, but was readily cured with a blood patch.

This was the only case of its kind in 13 000 obstetric epidurals in the 10 years 1978 through 1987. Re-usable Tuohy needles were then replaced with disposable ones and in the first 3 months of 1988 there were three further cases in which low pressure headaches followed uneventful epidural blocks with normal dose requirements and speed of onset. All required blood patches for their relief, and all were inserted by junior anaesthetists trained with re-usable needles.

In 1980 Ravindran and his colleagues[9] reported that of 352 gravidae, five had typical spinal headaches after normal epidural analgesia (an incidence of 1.4%), four of whom needed blood patching. They pointed out that partial dural puncture was more likely with disposable needles, which tended to be sharper than re-usable ones.

Sequence 3. The catheter penetrates arachnoid immediately: positive aspiration test with catheter, but not Tuohy needle.

It is so well recognised that a catheter may enter the subarachnoid space although cerebrospinal fluid (CSF) has

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not come back through the needle, that it does not merit reporting in the literature. There have been two documented cases in a series of 14 000 obstetric epidurals in this hospital, in which although no CSF emerged from the Tuohy needle, a catheter was passed directly into the subarachnoid space, and CSF aspirated, before any local anaesthetic was injected. Force was used on the catheter in at least one of these. Difficulty in passing a catheter is a common problem that does not merit reporting. This may often be accounted for by dural tenting or lateral penetration of the epidural space, but in at least some cases it may be that the needle bevel is at least partly in the subdural space.

Sequence 4. The catheter enters the subdural space and the test dose the subarachnoid space: positive test dose after negative aspiration.

This sequence has been considered by Scott[10] to be so unlikely as not to warrant the delay involved in giving a test dose. Moreover, Prince and McGregor[11] state that a high block has never been reported after a properly conducted epidural catheter test dose. They suggest that differentiation between epidural and subarachnoid injections of small volumes of local anaesthetic may be a 'problem in the parturient, whose judgement is often clouded by pain, panic and pethidine'. However, in at least two cases out of 14 000 in this hospital, both of whom received 2 ml test doses of 0.5% bupivacaine in the lateral position after negative aspiration tests, rapid onset of blockade to T_4 resulted, which in each case was readily recognised by the mother. Such cases would not normally be regarded as worth reporting, but for the statement of Prince and McGregor.[11] In both cases, *after* spinal blockade occurred, aspiration yielded CSF (confirmed by Dextrostix) and analgesia lasted throughout labour, but only one woman suffered a spinal headache, which necessitated a blood patch. A 3-holed catheter was used in each case, so false-negative aspiration is unlikely, and it would be far-fetched to suggest that catheter migration would occur in the instant between aspiration and test dose injection. The likely explanation is that the test dose given through a catheter placed in the subdural space causes the arachnoid to tear.

Sequence 5. Catheter and test dose remain in subdural space, the main dose enters subarachnoid: negative test dose followed by total spinal blockade.

Accidental total spinal anaesthesia is an acknowledged complication of attempted epidural blockade, and is reported after negative aspiration and negative test dose.[12,13] It has sometimes been assumed that the anaesthetist has been over-hasty or careless, that the test dose has been inadequate or the patient confused,[11] yet the logical explanation is subdural catheter placement with tearing of the arachnoid only on injection of a *large* volume. No case has occurred among the mothers delivered at this hospital.

Sequence 6. Main dose remains in subdural space: subdural block.

The picture of a delayed onset, excessive spread and sometimes unexpectedly profound blockade has come to be recognised as the result of subdural, extra-arachnoid placement of local anaesthetic. X ray studies using contrast medium[1-6] demonstrated the typical 'railroad' appearance. Boys and Norman[1] suggested that the clinical picture is not that of the 'massive epidural' described by Dawkins, since epidural spread of local anaesthetic would not account for the sparing of the circulation and motor function that is sometimes described,[1,2,6] although hypotension may also follow authenticated subdural block[3]. Such a picture has also been reported after caudal injection of bupivacaine,[14] though the probability of subdural block was unrecognised by the authors. Subdural blockade has also been reported during infusion of bupivacaine and pethidine into the epidural space in the management of chronic pain.[5] Excessive spread from C_6–S_5 was discovered after 4 days of normal sensory blockade between T_{12} and L_4. This was reported as subdural migration of a single end-hole catheter. There was no headache afterwards. Lubenow *et al.*[15] stated that the subdural space could be identified on myelogram in 1–13% of patients, and reported an incidence of 0.82% of subdural blockade among attempted epidurals.

Persistent unilateral block is also encountered from time to time in epidural practice. The most obstinately and totally unilateral blocks are readily corrected by reinsertion in our experience.

Case history. A 34-year-old multipara had an epidural catheter inserted in the $L_{3/4}$ interspace at 3 cm cervical dilatation. Ten ml of 0.25% bupivacaine produced a unilateral block which persisted despite withdrawal of the catheter 1 cm and two further doses of 8 and 6 ml 0.25% bupivacaine. Good pain relief followed catheter resiting, and after two more top-ups a normal delivery ensued. The woman felt well the next morning until she bathed the baby at midday, when she noticed a severe headache. This was helped by lying down, and 2 days later was relieved by blood patch, but recurred next day and required a second blood patch on the fourth postpartum day.

X ray and clinical evidence indicate that on subdural injection fluid is sometimes confined to one side only.[2,3] Resiting the catheter epidurally in such a case would correct a unilateral block, and subdural placement is therefore a much more likely explanation of this phenomenon than is a dorsomedian band in the epidural space.

Sequence 7. Catheter partly subdural, late arachnoid tear: delayed total spinal.

A delayed total spinal block late in the course of continuous epidural analgesia is regularly reported,[16-18] but has not occurred during the 14 000 obstetric epidurals monitored at this hospital. This notorious nightmare is commonly attributed to catheter migration, and because it is recognised that a soft epidural catheter cannot of itself penetrate the dura,[7] the phenomenon may be ascribed to partial subarachnoid placement of a 3-holed catheter which later migrates inwards.[19] However, delayed total spinal blockade is reported with the use of a single end-hole catheter,[16] just as is subdural blockade[5,6] and the problem occurs after *increasing* injection volumes[18] as in sequence 4. A related problem is 'the spinal that didn't happen'. Stirt[20] reported a case in which after Caesarean section under an apparently normal epidural block, CSF was seen to drip out of the catheter. In a similar case at this hospital, after an uneventful epidural for labour and delivery, the mother suddenly complained of headache, and it was found that CSF could be aspirated from her catheter, although bupivacaine dose requirement, onset and duration of analgesia had all been characteristic of a normal epidural block.

A test dose has been advocated before every top-up to guard against delayed spinal blockade,[17,20] since both the delayed total spinal and the 'spinal that didn't happen' are commonly attributed to catheter migration. An aspiration test would however be more logical than a test dose, provided, of course, a 3-hole catheter is in use. Thus, if the arachnoid has not torn with previous full doses of local anaesthetic it is unlikely to do so because of a test dose, while if it has already given way aspiration should be positive. Even if catheter migration is the explanation, this is unlikely to occur in the instant between aspiration and test dose, while if it has already occurred aspiration will reveal it.

Sequence 8. Injected solution enters two or more sites: composite block.

In a study in pain patients, Mehta and Salmon[21] demonstrated that radiopaque dye injected down Tuohy needles thought to be in the epidural space frequently entered both epidural and subdural spaces. This so-called 'partially inaccurate placement' occurred in 17% of cases.

It is apparent that not every case of delayed total spinal follows a subdural block, although typical subdural analgesia preceding a total spinal[16,18] may go unrecognised. The variable distensibility of the subdural space[8] influences not only the tendency for the arachnoid to tear, but also, if the injection rate is slow enough to hinder tearing, the amount of solution that enters the epidural space, either via proximal catheter holes or by leakage back round the catheter. Moreover, even once the arachnoid is broached, blockade of mixed origin can still occur.[16]

Case history. A 19-year-old primigravida in labour at term requested epidural analgesia at 3–4 cm cervical dilatation. The epidural space was entered at $L_{2/3}$ using loss of resistance to saline. Catheter insertion required some manipulation but not excessive force. A test dose of 3 ml bupivacaine 0.5% produced no change, after negative aspiration, and a further 3 ml produced pain relief, sympathetic blockade of the legs and pinprick analgesia to T_8 bilaterally. A second dose of 12 ml 0.25% bupivacaine was given 75 minutes later for perineal pain. Pain relief ensued gradually and after about 45 minutes she complained of feeling weak and numb all over and of difficulty in breathing. Her ventilation, however, appeared adequate and her legs not unduly weak; she was normotensive, able to swallow, had a left Horner's syndrome which soon became bilateral, and a T_2 sensory level. There was no fetal distress, and no resuscitation was necessary. When 165 minutes later she received a further top-up it was ineffective and the epidural catheter was found to have come out. A second cathether was easily inserted in the same space and aspiration was negative, but a 3-ml test dose of bupivacaine 0.5% produced a rapid onset of sensory block to T_{10} and complete motor block of both legs. Analgesia lasted until the spontaneous delivery of a healthy baby 2.5 hours later. The catheter was left *in situ*, because of its uncertain location, and the next day 5 ml metrizamide was intro-

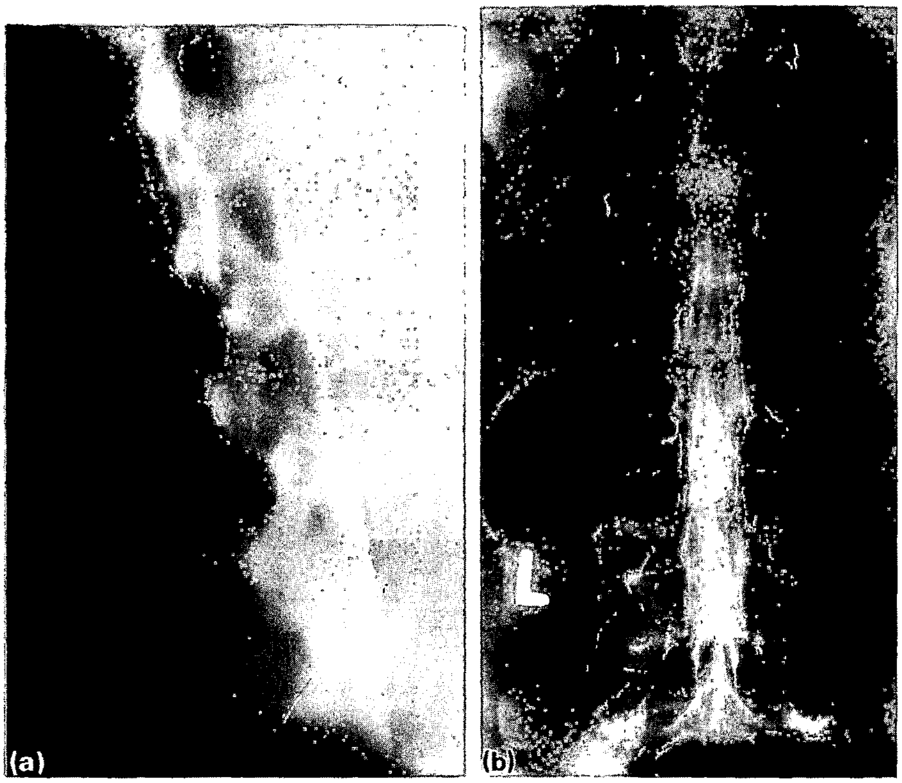

Fig. 1. (a) Initial injection of contrast medium with the patient prone shows a straight-sided appearance typical of the subdural space. The caudal end of the dural sac was viewed on fluoroscopy but unfortunately was excluded on the radiographs. (b) A later radiograph shows contrast medium outlining nerve roots and therefore in the subarachnoid space. Lateral views also suggested contrast medium in the epidural space.

duced under fluoroscopic control. This showed that the catheter was subdural, and contrast was seen to spread in the epidural, subdural and subarachnoid spaces, although only two of these were immortalised on celluloid (Fig. 1). The catheter was removed and no precautions were taken to avoid spinal headache. No blood patch was required.

There was both clinical and radiological evidence of spread of solution in all three sites in this case. Thus the first dose of bupivacaine produced epidural block, the second, larger volume, subdural, while the fourth dose entered the subarachnoid space. Both catheters, therefore, entered the subdural space and CSF aspiration was never possible. Catheter migration was unlikely, but between the second and fourth top-ups the arachnoid must have torn, to allow local anaesthetic, and later contrast, to enter the subarachnoid space. It would clearly have been wiser, with evidence of subdural blockade from the first catheter, to choose another space for the second catheter insertion.

Sequence 9. Neurological sequelae.

Subdural injection of local anaesthetic may be followed by unduly prolonged blockade,[22] but permanent neurological sequelae may follow accidental subarachnoid block;[12,13,18] the most recent reports implicate chloroprocaine. Accidental total spinal itself implies initial *subdural* catheter placement, and some subdural leakage is not uncommon during deliberate subarachnoid injection.[6] Fluid trapped in the relatively confined subdural space could well compress nerve roots and the accompanying radicular arteries. Similarly, a subdural haematoma can result in permanent neurological sequelae.[23] Thus, while the subarachnoid injection of large volumes of an inappropriate formulation of local anaesthetic, with low pH or containing preservative or anti-oxidant, may account for neurological sequelae of accidental total spinal blockade, as may profound hypotension,[24] an alternative cause may well be inadvertent subdural administration.

Conclusion

Subdural needle or catheter placement may well be commoner than has been supposed, and may account not only for delayed onset, profound and extensive conduction blockade, but also for 'unexplained' postepidural headaches, false negative aspiration tests and test doses, accidental total spinal, both early and late, some unilateral block and 'unexplained' neurological sequelae of spinal and epidural blockade. The most commonly used safeguards, aspiration and the test dose, are designed to detect intravascular and subarachnoid misplacements, but they cannot detect subdural misplacement.

It is most important to avoid dural damage by the Tuohy needle in the first place. It is logical to suppose that the ideal technique must be to approach the epidural space by constant pressure on the plunger of a saline-filled syringe[25,26] so that the instant the needle tip enters the space the dura is blown away, rather than to use intermittent advancement with loss of resistance to air.

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Anaesthesia, 1990, Volume 45, pages 124–127

CASE REPORT

Malignant hyperthermia during isoflurane anaesthesia

N. McGUIRE AND W. R. EASY

Summary

Two cases are presented which illustrate the essential features, diagnosis and management of malignant hyperthermia. Both cases occurred in association with isoflurane, and in patients who were exposed during previous anaesthetics to recognised trigger agents without apparent manifestation of the syndrome.

Key words

Anaesthetics, volatile; isoflurane.
Hyperthermia; malignant.

Malignant hyperthermia (MH) is an important condition, the inherited tendency to which carries an overall mortality of approximately 21%.[1] This is an improvement on the mortality of over 70%[2] associated with the condition before sodium dantrolene was discovered to be of value in the acute management of the syndrome, but is still unacceptably high. Early recognition is important and prompt treatment essential. Previously uneventful anaesthesia is not an indicator of nonsusceptibility, even if known trigger agents have been used.[3] MH may be triggered in susceptible individuals by a variety of agents, but particularly by suxamethonium and halothane. Nitrous oxide was thought to act as a trigger,[4] but is no longer considered to do so. All volatile agents have been implicated but isoflurane has been associated with only one case[5] which has been confirmed by the definitive investigation (muscle biopsy and contracture testing) and five cases[6–10] which have not been so substantiated. We report two further cases in which isoflurane administration was associated with confirmed MH.

Case 1

A 49-year-old Royal Air Force pilot presented for excision of Dupuytren's contracture of the right hand. Routine preoperative assessment revealed that he had undergone at least four previous general anaesthetics, apparently uneventfully. He had received both halothane and suxamethonium in conjunction with thiopentone and nitrous oxide for the last two procedures; anaesthetic records for the other procedures were not available. There was nothing else of consequence in his past history, and no significant abnormalities were found on examination. He was therefore assessed as ASA grade 1. He was premedicated with temazepam 30 mg and hyoscine 0.6 mg orally 2.3 hours before induction. Blood pressure (BP) measured in the anaesthetic room was 135/70 mmHg and heart rate 80 beats/minute. Induction of anaesthesia was with fentanyl 50 μg and thiopentone 350 mg. He was given suxamethonium 100 mg when the eyelash reflex was lost, and his trachea was intubated without difficulty. Ventilation was assisted manually via a Bain coaxial system with 3% isoflurane and 30% oxygen in nitrous oxide until spontaneous breathing returned. A pneumatic tourniquet was applied to the right upper arm and he was transferred into the operating theatre where the breathing system was changed to a circle system with absorber, with the vaporizer outside the circle. BP and electrocardiogram (ECG) were monitored. Expired carbon dioxide was not monitored because of a malfunctioning capnograph. Fifteen minutes after induction BP was 122/62 and heart rate 80 beats/minute when it was noticed that his upper trunk, neck, and ear-lobes were dusky. Ventilation appeared normal, auscultation of the chest confirmed normal air entry bilaterally and equipment checks revealed no faults. Nevertheless the breathing system was changed back to a coaxial system, the fractional inspired oxygen concentration (FIO_2) was increased to 0.5, the isoflurane concentration decreased from 1.5% to 0.5% and ventilation was controlled manually. His colour returned to normal with these measures and surgery proceeded with incremental fentanyl. The heart rate increased slowly until 55 minutes after induction it was 108 beats/minute but BP remained about 125/60. Cyanosis was noted again and the axillary temperature was measured; it was 38.2°C. Axillary temperature increased to 39.2°C over the next 20 minutes and the tachycardia increased to 135 beats/minute. A presumptive diagnosis of MH was made at

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this point, which coincided with the end of surgery. Oxygen 100% was administered through a 'clean' anaesthetic machine, intravenous fluids were started, rectal temperature was measured continuously and direct arterial monitoring established. Blood was taken for biochemical analysis and arterial blood gas measurement. Early management included the administration of dantrolene 1 mg/kg, intravenous sodium bicarbonate 150 mmol and surface cooling with ice. Initial blood gas results showed a marked metabolic acidosis; pH was 7.2, bicarbonate concentration 15.4 mmol/litre and base deficit 11.2 mmol/litre. pH was restored to 7.37, serum bicarbonate to 22.7 mmol/litre and base deficit to 1.6 mmol/litre within 30 minutes. No major disturbance of serum potassium occurred. Rectal temperature reached a peak of 40°C. He was transferred to the intensive therapy unit (ITU) and forced alkaline diuresis was instituted using intravenous sodium bicarbonate. Subsequently, the presence of free myoglobin in the urine was confirmed biochemically. The alkaline diuresis was continued until myoglobin was no longer detected in the urine (72 hours later). He remained fairly stable during this period except for a transient increase in temperature to 38.2°C after 24 hours which settled spontaneously. He was discharged from inpatient care a week after his anaesthetic, but biochemical normality was not restored for a further 4 weeks, and he experienced muscle discomfort throughout this time. Subsequent muscle biopsy at the Leeds Malignant Hyperthermia Investigation Unit confirmed the diagnosis.

Case 2

A 30-year-old woman presented for mandibular and bimaxillary anterior segmental osteotomies. Special attention was paid at the pre-operative anaesthetic visit to mouth opening and jaw morphology; no difficulty with intubation was anticipated and she was assessed as ASA grade 1. Her previous medical history revealed that she had received two general anaesthetics in the past; the first at the age of four for adenotonsillectomy, the other at the age of 13 for reduction of a fractured forearm. The anaesthetic records for both of these procedures had been destroyed, but they had been uneventful as far as the patient was aware. She was premedicated with temazepam 20 mg and hyoscine 0.6 mg orally 2 hours before operation. Anaesthesia was induced with papaveretum 10 mg, thiopentone 250 mg and suxamethonium 75 mg. Laryngoscopy proved impossible because of restricted mandibular opening, and spontaneous ventilation was re-established using 60% nitrous oxide and 5% isoflurane in oxygen. Intubation was achieved 'blind' by the nasal route. Alcuronium 15 mg was administered and the patient's lungs were ventilated by means of a Nuffield 200 series ventilator (Penlon) and circle system with carbon dioxide absorber. BP and ECG were monitored. A Normocap (Datex) was used to measure inspired oxygen but the expired carbon dioxide was not monitored since the patient's head was too far from the monitoring trolley; the sampling tube was positioned in the inspiratory limb of the circle system to measure FIO_2 alone. It was noted early in the anaesthetic procedure that she had a tachycardia of 140 beats/minute and this increased over the succeeding 45 minutes to 160 beats/minute. She was given droperidol 5 mg and propranolol 0.6 mg; the heart rate decreased to 120 beats/minute but increased again over the next 30 minutes to 150 beats/minute. Her nail beds were noted to be cyanosed after 1.25 hours of anaesthesia. The surgeon coincidentally remarked that the blood appeared to be darker in the wound. The breathing system and ventilatory variables were checked, and the fractional inspired oxygen concentration was increased to 0.5. The patient was noticed to be very warm a few minutes later. A presumptive diagnosis of malignant hyperthermia was made 1.5 hours after induction of anaesthesia, and surgery was terminated. A rectal temperature probe was inserted and the temperature found to be 39.5°C. Active surface cooling was started, dantrolene was given in a dose of 1 mg/kg intravenously, venous and arterial blood samples were sent for analysis, and direct arterial pressure monitoring was instituted. Early blood chemistry results revealed profound acidosis and a degree of hyperkalaemia; two intravenous infusions were started (10% dextrose with insulin, and sodium bicarbonate). Ventilation was continued with 50% nitrous oxide in oxygen. The rectal temperature increased to 40°C but biochemical analyses and blood gases had returned almost to normal one hour later. Forced alkaline diuresis was instituted and she was transferred to the intensive therapy unit. Myoglobinuria was present for the next 2 days, and 24 hours after this ceased she was transferred back to the ordinary postoperative ward and subsequently discharged from hospital 10 days after her anaesthetic. The diagnosis of MH was confirmed later by muscle biopsy at the Leeds MH Unit, and her mandibular osteotomies were performed uneventfully under general anaesthesia 2 months later.

Discussion

Malignant hyperthermia susceptibility (MHS) is rare but the true incidence is uncertain. Estimates vary from 1:14 000 amongst children[1] through 1:110 000[12] to 1:120 000[13] overall. Ording[14] suggests that fulminant MH occurs in 1:250 000 anaesthetics of all types but with an incidence of 1:50 000 with inhalational agents used in conjunction with suxamethonium, and that abortive MH may occur in as many as 1:4300 cases when inhalational agents are used after suxamethonium. Definitive diagnosis can be made only by *in vitro* muscle testing, but many of the cases reported have not been confirmed by this method; most of the previously reported instances of MH in association with isoflurane belong to this category. Confirmation is particularly important since MH is an inherited condition and there are obvious implications for other family members.[15] Many methods of testing have been proposed and include the measurement of serum creatinine kinase,[16,17] serum cholinesterase[18] and tests on erythrocytes, platelets and white cells.[17-24] A number of electrophysical tests have been investigated but have not proved helpful.[25-27] Measurement of intracellular ionised calcium concentration and nuclear magnetic resonance scanning require further investigation, but may prove helpful.[17] Histological examination is not of value in the positive diagnosis of MH, but is used to exclude other myopathies. At the present time the only reliable tests with reproducible results are the contracture tests, the two most commonly used being with caffeine and halothane. More reliance is placed on the halothane test, which is believed to have a greater sensitivity, but the caffeine test is also performed to conform with the standardisation of the European MH Group.[28, 29]

The majority of MHS individuals do not appear to have any underlying or associated disease, but some associations with central core disease,[30] Duchenne muscular dystrophy,[10,31,32] King–Denborough syndrome[33] and myoadenylate deaminase deficiency[34] have been supported by *in vitro* muscle testing. Coincidental association only is assumed with sudden infant death syndrome and neuroleptic malignant syndrome.[35]

The site of the abnormality in MH has been debated since it was first described by Denborough and Lovell in 1960[36] but it is now generally accepted that the primary lesion lies in the sarcoplasmic reticulum (SR) of skeletal muscle.[1,37] The massive amount of heat that is released from the muscle in MH is generated by the uptake of calcium by the SR which uses adenosine triphosphate (ATP), the hydrolysation of ATP by the contractile element, and the heat of neutralisation of pyruvate. The temperature regulating mechanisms are not affected by the abnormality *per se,* but their actions are obtunded by anaesthesia. The precise location of the lesion in the SR is not yet known, but it is established that dantrolene blocks the calcium channels in the terminal cisterns of the SR.[1] The mode of triggering of MH has also been difficult to elucidate, but the simplistic view of a straightforward triggering agent is no longer valid as it is now recognised that MHS individuals may have had previously 'uneventful' anaesthesia with one or more of the known trigger agents. MH in the porcine model can be triggered by stress, and it has been proposed that this may be a factor;[38–40] however, there is no satisfactory evidence for this in man. The incompletely explained nature of triggering has led some workers to suggest that an MH episode requires: an inherited predisposition; internal and external qualifying factors which establish or protect from vulnerability; and the presence of triggering agents or conditions.[41] It is clear that the initiation of the events that produce MH is a complex problem which requires more research.

Successful management is dependent initially on recognition. The 'classical' signs include muscle rigidity and trismus, which may not be present in MH; indeed, they may follow the administration of suxamethonium in up to 45% of normal individuals.[42,43] A rapid increase in temperature may occur, but this can occur also in thyrotoxic crisis.[44] An increase of 1°C/hour is quoted as one of the diagnostic criteria in MH; it may well be much faster. Tachycardia was a presenting feature in both cases reported here, and is said to be a constant feature, but it may also be a consequence of many other factors such as insufficient depth of anaesthesia, inadequate analgesia, or intercurrent disease such as thyrotoxicosis. It may be caused by isoflurane alone.[45] Tachypnoea may occur, but in the absence of end-tidal CO_2 monitoring might be attributed to the same causes as tachycardia. Cardiac arrhythmias may occur in patients treated with almost any inhalational agent, or in the presence of CO_2 retention, hypoxaemia or ischaemic heart disease. Unstable blood pressure can occur with any one of a large number of factors associated with anaesthesia, surgery and pre-existing disease. Cyanosis has multiple causes, the search for which could delay suspicion and diagnosis of MH. The key to rapid and correct diagnosis would appear to lie in an acute awareness of the disease together with the rapid but considered dismissal of other causes for the group of signs which may present.

Treatment priorities are generally held to be: cessation of volatile agents; administration of 100% oxygen (by a 'clean' anaesthetic machine if available); correction of acidosis and biochemical abnormalities, cooling, administration of sodium dantrolene and renal protection. Rapid infusion of intravenous fluids, cooled if possible, should be started; compound sodium lactate solution is contraindicated because it contains potassium, lactate and calcium. Most authorities advocate rapid cessation of surgery, but some advocate treatment simultaneously with surgery (personal communication, H. Ording). Sodium dantrolene should be given as an initial bolus of 1 mg/kg, and if the temperature continues to increase or has not started to decrease within 30 minutes, 0.5–1 mg/kg increments may be given up to a maximum of 10 mg/kg. It is imperative that core temperature is monitored continuously to establish the trend. Electrocardiographic and blood pressure monitoring is mandatory during every anaesthetic, and more invasive monitoring such as urinary output, central venous pressure and direct arterial pressure should be established as soon as possible. The early collection of venous and arterial blood samples to establish baselines is invaluable. Sodium bicarbonate (1 mmol/kg) should be given initially, but more may be required later. Large quantities of ice should be applied over wet surgical drapes to the axillae and groins (where large vessels are superficial) and abdomen and lower limbs (where skeletal muscle mass and surface area are large). Peritoneal lavage with cold saline has been advocated. There is usually an increase in serum potassium concentration and the administration of glucose and insulin should be considered. Arrhythmias may occur; rapid correction of the metabolic disturbances is the treatment of choice but anti-arrhythmic drugs may be required if arrhythmias persist or are dangerous. The patient should be transferred to the intensive therapy unit where monitoring of all variables previously described is continued and frequent measurements of blood urea and electrolyte concentrations, liver function tests, arterial blood gases and urine output performed.

Two major late complications may occur. The first of these is disseminated intravascular coagulation; clotting should be checked at least twice in the first 12 hours or more frequently if there are signs of abnormal bleeding from surgical wounds. The second is the development of renal failure which may occur early because of inadequate fluid replacement, or later due to the toxic effects of myoglobin. Myoglobin is highly toxic to the renal tubule when in an acid environment, and alkalinisation of the urine should be instituted. The continuance of oxygen therapy or positive pressure ventilation is guided by blood gases and other factors such as the nature of the surgery performed. Movement should be restricted during the first 48 hours since any muscular effort increases release of myoglobin from damaged muscle.

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CASE REPORT

Monitoring of curarisation in patients with tetraparesis

F. FIACCHINO, M. BRICCHI AND G. LASIO

Summary

Neuromuscular blockade induced by pancuronium was monitored on the trapezius and abductor digiti minimi muscles in three patients with upper motor neurone lesions: one patient was hemiparetic and two were tetraparetic. A greater sensitivity to pancuronium was always observed on the trapezius muscle. It is suggested that the assessment of curarisation is more reliable on proximal than on distal muscles if the patient's sensitivity to relaxants is expected to be generally low.

Key words

Neuromuscular relaxants.

Resistance of centrally denervated muscles to the action of non-depolarising relaxants[1] can cause curarisation to be underestimated in patients with hemiparesis,[2-5] and underestimation of block is likely to be even greater in patients with tetraparesis.

We report clinical observations which indicate that trapezius muscle monitoring could be a more reliable indicator of neuromuscular blockade in patients whose sensitivity to non-depolarising relaxants is expected to be low.

Methods

Neuromuscular transmission was monitored by a Medelec 'MS 92a' and one or two Datex Relaxograph NMT monitors. Surface electrodes were used in all circumstances. The Datex unit was calibrated with supramaximal stimulation to obtain the 100% reference value, after anaesthesia was induced and before administration of any muscle relaxants. A train-of-four stimulation at 2 Hz was then given every 20 seconds to the motor nerve of the appropriate muscle. Single twitch depression and train-of-four fade ratio were continuously recorded by the Datex unit. Depression of twitch height was taken as the ratio between the first evoked muscle potential in a train and the 100% reference value obtained at calibration (T_1–T_c). Fade was displayed as the ratio between the fourth and the first response in each train (T_{4-1}). The Medelec unit was used to assess the train-of-four ratio only. Skin temperature was not monitored. Ventilation during anaesthesia was adjusted to produce a normal end-tidal carbon dioxide concentration, and the heart rate was recorded with an ECG monitor.

Case histories

Patient 1, a 55-kg, 22-year-old tetraparetic woman, was scheduled for tracheostomy 20 days after removal of a medulloblastoma of the cerebellar vermis. The postoperative course was complicated by hypertensive hydrocephalus and a ponto-mesencephalic infarction. The patient was uncooperative.

Premedication, with diazepam and atropine, was followed by anaesthesia induced with fentanyl and thiopentone and maintained with divided doses of thiopentone and a continuous infusion of fentanyl. Three divided doses of pancuronium (1 mg) were administered some minutes after the calibration of the Datex unit, which resulted in a T_1–T_c ratio of 0.9 and a T_{4-1} ratio of 0.45 on the right *abductor digiti minimi* (Fig. 1). Forty-five minutes after calibration, two attempts were made to assess the degree of neuromuscular blockade in the right trapezius by the Medelec unit (marks 4 and 5 on Fig. 1). The T_{4-1} ratio was 0.20 on the trapezius on each occasion (not shown in the figure) while recovery from curarisation was almost complete on the *abductor digiti minimi.*

Anaesthesia was started again more than one hour later and the sensitivity to pancuronium was again assessed after administration of small doses of the drug (0.2 mg at mark 1 and 0.5 mg at mark 2). This time the Datex unit was used to monitor the trapezius, and the Medelec unit was used to monitor the *abductor digiti minimi.* The striking difference in sensitivity to pancuronium between the distal and the proximal muscle was confirmed: T_1–T_c ratio was 0.5 and T_{4-1} ratio was 0.1 on the proximal muscle, while stimulation of the ulnar nerve (marks 2, 4–7) showed no evidence of block.

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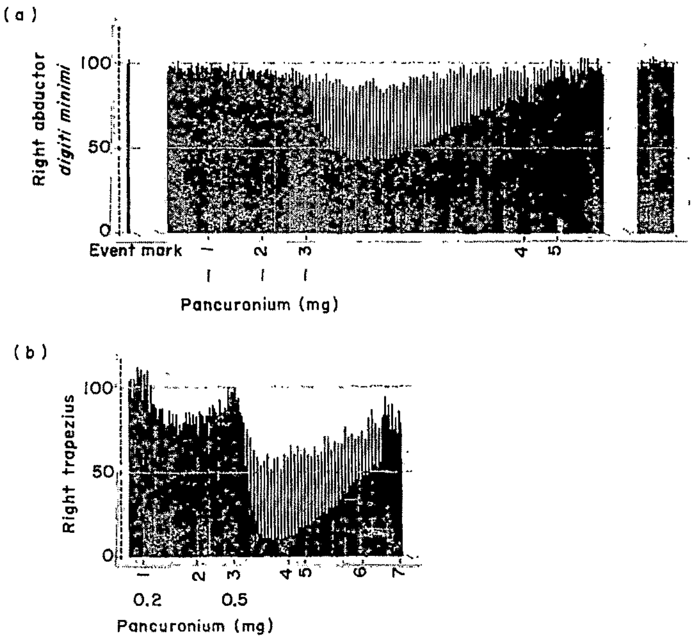

Fig. 1. Datex Relaxograph traces in two successive anaesthetics (a) and (b) in a patient with tetraparesis (patient 1). The effects seen on each occasion were compared with the train-of-four response seen in the other muscle at the same time. (See text for identification of the event marks.)

Patient 2, a 45-kg, 12-year-old tetraparetic boy was admitted to hospital because of malfunction of a ventriculoperitoneal shunt which had been implanted 11 years before. Fetal toxoplasmosis was followed by acqueduct stenosis and severe psychomotor abnormalities. Carbamazepine treatment had been started when the patient was 8-years-old. He had marked spastic tetraparesis, decorticate posturing and serious mental impairment on admission.

Premedication, with diazepam and atropine, was followed by anaesthesia induced with fentanyl and thiopentone and maintained with nitrous oxide and a continuous infusion of fentanyl. Neuromuscular blockade was assessed by the simultaneous use of two Datex units: one to monitor the right *abductor digiti minimi*, and the other to monitor the left trapezius (Fig. 2).

The trachea was intubated without difficulty after a cumulative dose of pancuronium 3 mg. Intubation was accomplished when curarisation was hardly demonstrable in the distal muscle and almost complete in the proximal one. The administration of a third dose of pancuronium (1 mg) some minutes later confirmed the greater sensitivity of the trapezius to pancuronium.

Patient 3, a 60-kg, 23-year-old woman was admitted to hospital because of recurrence of a right frontal ependymoma which had first been removed 10 years before. The postoperative course was complicated by a transient left hemiparesis and by frequent epileptic fits. The patient had been treated with phenobarbitone. She had a slight left hemiparesis on admission.

Premedication, with phenobarbitone and atropine, was followed by anaesthesia induced with thiopentone and maintained with nitrous oxide and halothane. The trachea was intubated after administration of 10+75 mg succinylcholine. Thirty minutes later, two Datex units were calibrated for simultaneous assessment of neuromuscular blockade in the right trapezius and the right *abductor digiti minimi*. Pancuronium 1 mg was administered and the same dose was repeated 10 minutes later. A greater sensitivity to pancuronium was observed in the trapezius muscle on both occasions (Fig. 2(b)).

Discussion

The percentages of type I and type II fibres are approximately the same in trapezius and *abductor digiti minimi* muscles of young adults.[6] Fibre type distribution, therefore, does not modify the greater curarisation of trapezius seen in our patients. Curarisation should be monitored on muscles contralateral to the side of paralysis in patients with hemiparesis.[2-5] This was possible in patient 3, but not in patients 1 and 2. Moreover, Shayevitz stated that sensitivity to curare on the supposedly unaffected side is greater than on the affected side, but still significantly less than in patients with normal motor strength.[4]

This observation prompted us to ascertain whether proximal monitoring was a more reliable method to detect neuromuscular blockade in patients with upper motor neurone lesions. Curarisation[7] and myasthenia gravis, from a neurophysiological point of view,[8] are both assessed by the same diagnostic technique. We performed our investigations on the assumption that the neuromuscular margin of safety was lower (and sensitivity to pancuronium higher) in proximal compared with distal muscles, since the diagnostic yield for this technique was reported to be greater for proximal than for distal muscles.[8] We cannot establish, however, whether differences in margin of safety or differences in 'decentralisation' were responsible for the greater sensitivity to pancuronium observed in the trapezius

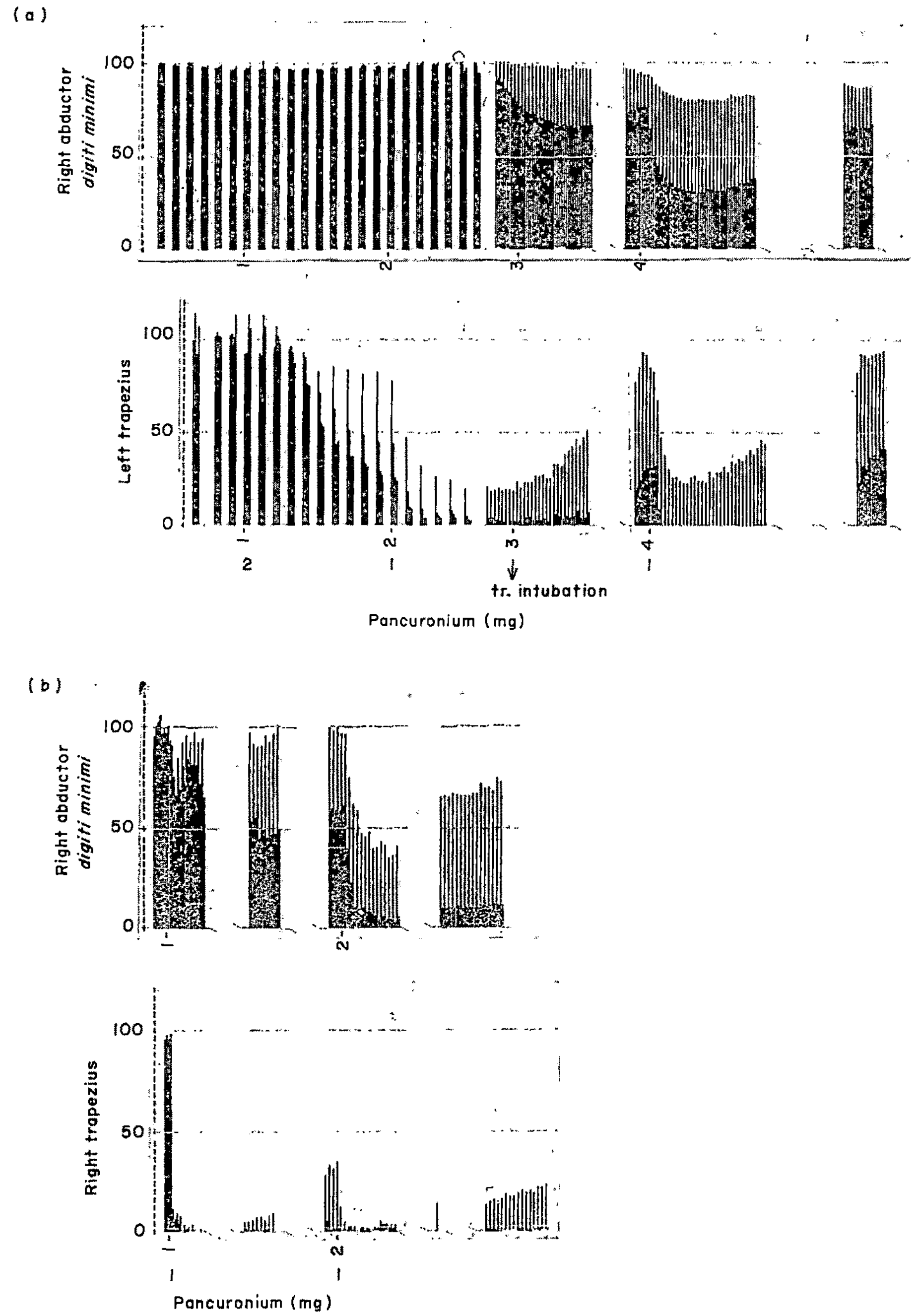

Fig. 2. Simultaneous recording of the Datex Relaxograph in two muscles in patients 2(a) and 3(b). (Stimulus rate 2 Hz.) The time scale in patient 2 is expanded at the beginning of the trace.

muscle. Trapezius function, but not sternocleidomastoid function was reported to be lost on the affected side in hemiplegic children.[9] On the other hand, electromyographic evidence of 'central denervation' was reported to be much more frequent in distal than in proximal muscles of paretic limbs.[10,11]

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Anaesthesia, 1990, Volume 45, pages 132–134

CASE REPORT

Anaesthesia in a gravid achondroplastic dwarf

J. R. BRIMACOMBE AND J. A. CAUNT

Summary

A patient with achondroplasia presented for elective Caesarean section under epidural anaesthesia. A block from C_5 to S_4 developed over 20 minutes after 12 ml plain bupivacaine 0.5%. This case serves to highlight the difficulties of regional anaesthesia in the gravid achondroplastic dwarf.

Key words

Anaesthetic techniques; epidural, lumbar.
Genetic factors; achondroplastic dwarfism.

The anaesthetic management of the gravid achondroplastic dwarf offers a considerable challenge whether regional or general anaesthesia is chosen. The constricted maternal pelvis, marked lumbar lordosis and near-normal infant size make Caesarean delivery vital. Prompted by a request to perform an epidural in such a patient, we searched the literature but found little information with regard to doses of local anaesthetic drug or precisely how it should be administered. We discovered only two case reports, both from the United States, which involved the use of chloroprocaine 3.0%[1] and bupivacaine 0.75%.[2] There were no reports of the use of bupivacaine 0.5%.

Case history

A 24-year-old achondroplastic dwarf was admitted for elective Caesarean section. She was gravida 3 with no live children. Her first pregnancy produced an achondroplastic boy delivered by Caesarean section but he died at the age of 11 months as the result of a hyperextension injury to his neck. A subsequent pregnancy was terminated because of an antenatal diagnosis of achondroplasia.

The patient presented for elective Caesarean section at 38 weeks' gestation and wanted to be awake during delivery. Previous anaesthetics had been uneventful; it was noted that it was easy to intubate her trachea with a 6.5-mm tube. This pregnancy was uncomplicated apart from mild hydramnios. Ultrasonic measurements of femoral length suggested that the fetus was normal. Physical examination revealed a 73-kg, 121-cm healthy female achondroplastic dwarf with short limbs, large cranium and a depressed nasal bridge. Her trunk was abnormal; she had a marked lumbar lordosis, impalpable lower lumbar vertebrae and prominent lower back musculature. She was unable to obliterate the lumbar lordosis either in the lateral or sitting position and had a markedly contracted pelvis which excluded the possibility of vaginal delivery. Her blood pressure was 110/75 mmHg in the lateral position. No other abnormalities were noted on examination. Results of pre-operative investigations were unremarkable except that the haemoglobin concentration was 9.3 g/dlitre; two units of packed red cells were transfused.

The potential technical difficulties were discussed with the patient and she was prepared for the possibility that a general anaesthetic might be needed in the event of failure of epidural block. Thirty millilitres of 0.3 molar sodium citrate were administered, a 16-gauge intravenous cannula was inserted and 1.5 litres of compound sodium lactate solution infused. Epidural injection was attempted at the $L_{2/3}$ ($?L_{3/4}$) interspace. A 16-gauge Tuohy needle was used, but it was necessary to insert it at 45° cephalad to the skin in order to locate the ligamentum flavum. A loss of resistance technique with 1 ml of saline was used to identify the space at a depth of 6 cm, but catheter insertion was difficult and resulted in a bloody tap. A second attempt was made at the same interspace. The epidural space was identified successfully with 1 ml of saline and a further 9 ml were injected to open up the space to facilitate catheter insertion. Further difficulty was encountered when threading the catheter, but eventually it slid in and 3 cm were left in the epidural space. The manometer, gravity drain and aspiration tests indicated that the tip of the catheter was neither

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in the subarachnoid space nor in a blood vessel. A test dose of 2 ml plain bupivacaine 0.5% produced no evidence of subarachnoid block after 5 minutes and a dose of 5 ml plain bupivacaine 0.5% was given slowly in the sitting position. There was no evidence of block after 5 minutes and another dose of 5 ml plain bupivacaine 0.5% was injected, again in the sitting position. The block began to work after a further 5 minutes and the patient was placed in the modified supine position with 15° left lateral tilt. However, she developed weakness in her arms and bilateral Horner's syndrome 10 minutes later. There were no symptoms or signs of respiratory impairment. She remained normotensive and tests of temperature sensation with ice demonstrated a block from C_5 to S_4. Peri-anal sensation was not lost. The block did not extend subsequently. Tests for analgesia indicated that the block was satisfactory and surgery proceeded.

A 3.4-kg healthy boy, with Apgar scores of 7 at 1 minute and 9 at 5 minutes, was delivered without difficulty. The mother was monitored with a Dinamap, electrocardiograph and pulse oximeter. The short, obese upper limbs made some of the indirect blood pressure readings inaccurate, but she remained clinically well, and her oxygen saturation was satisfactory throughout the procedure. Surgery was uneventful. Total blood loss was 200 ml.

Analgesia was provided by epidural diamorphine 2.5 mg at 12-hourly intervals. The postoperative courses of the mother and infant were uneventful apart from a mild wound infection which resolved after treatment with antibiotics.

Discussion

Achondroplasia is the most common form of dwarfism with an incidence of 1 in every 26 000 births. Transmission is by autosomal dominant gene. Approximately 80% of cases represent spontaneous mutation; 20% are familial. Females are affected more frequently than males.[3] Achondroplastic dwarfs have low fertility rates. The basic defect is caused by poor development and premature ossification of bones that form from cartilage coupled with normal periosteal bone formation, and this leads to the characteristic craniofacial and spinal abnormalities.

Both general and regional anaesthesia pose problems for the pregnant achondroplastic dwarf. The trachea may be difficult to intubate[4–7] and a small tracheal tube is required; the correct size is predicted best according to weight.[7] Hyperextension of the neck should be avoided during tracheal intubation to prevent cervical cord compression, because foramen magnum stenosis is common. Cardiorespiratory function may be reduced by a narrow rib cage and a variable degree of kyphoscoliosis. The addition of a totally abdominal uterus compressed within the short distance between symphysis pubis and xiphoid can compromise cardiorespiratory reserve; respiratory acidosis has been reported in the recumbent position from the 24th week of pregnancy.[1] A low functional residual capacity reduces the safety margin provided by pre-oxygenation during rapid sequence induction. Some authors recommend arterial blood gas measurement as a pre-operative investigation.[2] High intra-abdominal pressures may put the mother at greater risk of aspiration.

Regional anaesthesia may be technically difficult because of poor landmarks, but many achondroplastic dwarfs have a normal back. A relatively narrow spinal canal may result in cord compression, prolapsed discs and deformed vertebral bodies. Neurological sequelae have not been reported after regional anaesthesia in the achondroplastic dwarf but it might be prudent to avoid it if pathology in the spine is present; some authorities suggest that regional anaesthesia should not be used beyond the second decade in life because of these problems.[2,8] A narrow epidural space may make catheter insertion difficult and a subarachnoid tap more likely. Recognition of a subarachnoid tap may be more difficult because free flow of cerebrospinal fluid may be difficult to obtain. As yet no recommendations have been made with regard to the correct local dose of anaesthetic drug. Epidural anaesthesia is preferable to spinal anaesthesia because it permits titration of the dose of local anaesthetic according to the height of the block.

Supine hypotension may be very severe, particularly during regional anaesthesia. Excess skin and subcutaneous tissue may make intravenous access awkward to establish. The gross anatomical deformities make monitoring more difficult and increase the risk of positional trauma.

There have been two previous case reports about the use of epidural anaesthesia for Caesarean section in achondroplastic dwarfs. Waugaman *et al.*[2] reported an uneventful anaesthetic in a 48-kg, 120-cm healthy female with a normal back to whom 21 ml of plain bupivacaine 0.75% was given in small increments to produce a block to T_3–T_4. However, Cohen[1] had great difficulty inserting a catheter into a 57-kg, 122-cm healthy female with a markedly lordotic back and produced a subarachnoid tap before correct placement of the catheter. A test dose of 3 ml chloroprocaine 3% and a main dose of 6 ml produced a block up to T_4. This was supplemented with a further 9 ml after 35 minutes.[1]

This case is the first to be reported using bupivacaine 0.5%. It indicates the difficulties associated with epidural anaesthesia for Caesarean section in achondroplastic dwarfs particularly with regard to dose selection. Catheter insertion was predictably difficult in this case, but the slow onset of the block and the retention of peri-anal sensation suggest correct placement in the epidural space. It may be that the use of saline to help catheter insertion contributed to the high block or that there was a degree of subdural or subarachnoid leakage. However, the most likely reason for the high block remains her narrow spinal canal and epidural space.

It is difficult to derive dosage guidelines for the use of local anaesthetics for spinal or epidural anaesthesia in the gravid achondroplastic dwarf because the use of X ray evaluation of the spinal canal is probably contraindicated. It is clear that small incremental doses of local anaesthetic should be titrated against the height of the block, but the slow onset of block with bupivacaine causes difficulty and a prolonged incremental interval is required. Perhaps an infusion technique using a drug with more rapid onset would be more appropriate. It may be unwise to use saline to facilitate catheter insertion.

The anaesthetic management of the gravid achondroplastic dwarf is a challenge. All patients must be assessed pre-operatively to identify potential hazards. The risks involved with epidural anaesthesia and the possibility of general anaesthesia must be discussed. Finally, adequate time must be made available for the insertion of the epidural and establishment of an adequate block.

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CASE REPORT

An unusual presentation of cardiac tamponade

M. C. BELLAMY, V. NATARAJAN AND R. J. LENZ

Summary

A case of pericardial effusion with tamponade that presented as an acute abdomen is described.

Key words

Heart; tamponade.

Case history

A 34-year-old woman presented to the general surgeons 3 weeks after a respiratory tract infection. This was complicated by retrosternal chest pain, attributed to a 'pulled muscle'. She felt increasingly unwell and in the week before admission developed upper abdominal pain and vomiting. She also 'fainted' on two occasions. A diagnosis of seropositive rheumatoid arthritis had been made 4 years before, and this was treated with naproxyn alone.

She was not cyanosed on examination, had an apparently normal jugular venous pressure, and a blood pressure of 80/60 mmHg. Her pulse rate was 110/minute and the heart sounds and breath sounds were said to be normal. The abdomen was generally tender, and gave an impression of fullness in the right hypochondrium. A full blood count showed a haemoglobin of 11.6 g/dlitre with a white cell count of 16.9×10^9/litre. The urea, electrolytes and amylase were normal. An AP chest film showed a possibly enlarged heart but no other abnormality. An ECG was not performed. A provisional diagnosis of peptic ulceration was made. The hypotension responded initially to 500 ml of gelatin and she was observed overnight. Her general condition had deteriorated by morning, so she was presented for surgery.

The patient's oxygen saturation, as measured by a pulse oximeter, decreased catastrophically to 65% and systolic blood pressure to 70 mmHg, after a rapid sequence induction with etomidate 10 mg and suxamethonium. Auscultation of the chest revealed reduced air entry into the left side, but withdrawal and subsequent exchange of the tracheal tube failed to rectify this. There was no clinical evidence of a pneumothorax, so central venous cannulation was performed and the right atrial pressure (RAP) was 24 mmHg.

Blood pressure was restored and oxygen saturation improved to 85% by an infusion of dobutamine, although the RAP remained elevated. Surgery proceeded while an on-the-table chest X ray was arranged. Laparotomy revealed gross hepatic congestion and ascites but no other pathology. The X ray showed increased cardiomegaly. A tentative diagnosis of tamponade was made, and needle aspiration of the pericardium yielded turbid fluid. A thoracic surgeon was called, who performed a pericardial fenestration and inserted pericardial and chest drains via a low midline thoracotomy. A litre of effusion was drained, with an immediate decrease in the RAP to 10 mmHg and an increase in blood pressure and oxygen saturation to normal. The dobutamine was discontinued. The patient was transferred to the Intensive Care Unit for postoperative management, where her recovery was rapid and uneventful. Echocardiography showed normal valvular and ventricular function. Cultures of the blood and pericardial effusion were negative, as were viral titres. Pericardial histology showed fibrinous pericarditis.

Discussion

Asymptomatic rheumatoid pericardial effusion is relatively common and may occur in up to 44% of cases,[1] although it is usually insignificant[2–4] and seldom progresses to constrictive pericarditis or tamponade; the crude prevalence rate for these are 0.64% in males and 0.06% in females.[5] The duration of rheumatoid disease before the development of pericarditis is variable but is usually not long-standing.[3,5] All are seropositive for a rheumatoid factor, and there is a high correlation with the presence of skin nodules.[3,6,7] Our patient fulfilled both these criteria. Cardiac tamponade in a healthy young woman has been described by Holloway *et*

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al.[8] as a presenting feature of connective tissue disease, and there are very close parallels between the clinical findings in this and our case. Diagnosis can be difficult, however, since the signs of tamponade (muffled heart sounds, third heart sound, rub) may be difficult to elicit, or even absent, as in this case.[5]

The most reliable diagnostic manoeuvre is cardiac catheterisation,[6] in which the diastolic pressures in the four chambers tend all to be increased and equalised. We did not attempt this because the diagnosis was previously unsuspected. We were further misled by the heart size on the initial chest X ray which we assumed was normal because the film was AP.

The treatment of choice for rheumatoid constrictive pericarditis and tamponade is surgical, and Thadani has reviewed 20 patients, in whom all those treated surgically survived whereas nine of the 10 treated medically died.[7] First- and second-line antirheumatoid therapy are ineffective in the prevention and treatment of pericarditis or tamponade. Steroids are also ineffective where the aetiology is rheumatoid,[9] but may be of value in other connective tissue disorders.[8]

We attribute hypoventilation of the left lung to compression of the left lower lobe bronchus by the enlarged pericardial sac that overlay the left atrium,[10] especially since hypoventilation had resolved by the time the patient arrived in the Intensive Care Unit. We are unaware of any other case of rheumatoid pericarditis with tamponade that presented as an acute abdomen and was diagnosed after the induction of anaesthesia.

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Anaesthesia, 1990, Volume 45, pages 137–139

CASE REPORT

The Brain laryngeal mask airway

An alternative to emergency tracheal intubation

I. CALDER, A. J. ORDMAN, A. JACKOWSKI AND H. A. CROCKARD

Summary

The laryngeal mask airway was used to resuscitate a patient in whom direct and fibreoptic laryngoscopy were impossible because of cervical pathology and pulmonary oedema. The laryngeal mask airway may be an alternative to tracheal intubation in emergency resuscitation.

Key words

Equipment; laryngeal mask.
Intubation; difficult.

The laryngeal mask airway* (LMA) was developed by Brain[1] as a device which could be inserted in a blind manner to provide an airway for anaesthesia. He also described the use of a prototype LMA to facilitate positive pressure ventilation of the lungs during anaesthesia. Subsequently, Brain[2] described three cases in which a prototype LMA was used for anaesthesia after tracheal intubation had been abandoned because the cords could not be visualised. A third paper[3] suggested use of the LMA to control the airway during emergency resuscitation. We had to use the device for this latter purpose within a week of its arrival at our hospital. Placement of the LMA was easy despite our lack of experience in its use, and resuscitation successful.

Case history

A 72-year-old woman who had suffered from rheumatoid arthritis for 12 years complained of severe neck pain and increasing weakness of the arms. A CT myelogram showed atlanto-axial subluxation with fracture of the odontoid peg, causing compression of the brain stem by translocation of the odontoid fragment. Transoral odontoidectomy and posterior occipito-cervical fusion with a Ransford Loop as described by Crockard[4] was scheduled.

Difficulties with tracheal intubation are expected in these patients[5] and our practice is to use a fibreoptic laryngoscope to position a nasotracheal tube under general anaesthesia. Direct laryngoscopy is then performed to facilitate the passage of a nasogastric tube. It was possible to see only the tip of the epiglottis at direct laryngoscopy, that is, Cormack and Lehane,[6] Grade 3. Surgery was uneventful, and the tracheal tube was removed on the first day after operation. Four days later the patient suddenly developed severe pulmonary oedema with frothing at the mouth, possibly as a result of airway obstruction.[7] We were faced with an urgent need to secure the airway in a situation in which tracheal intubation would have been difficult even with the fibreoptic laryngoscope, because of the copious froth. We therefore administered a sleep dose of propofol, inserted a size 3 LMA and inflated its cuff with 25 ml of air. This allowed positive pressure ventilation of the lungs with oxygen-enriched air delivered by a self-inflating bag. A formal tracheostomy was performed under general anaesthesia after the patient was transferred to theatre. Operating conditions were excellent. The pulmonary oedema resolved as a result of positive pressure ventilation and diuretic therapy.

Eighteen hours later accidental tracheal decannulation occurred. No track had formed and the tracheostomy tube proved impossible to replace. The patient became cyanosed and lost consciousness despite the insertion of an oral airway and attempted ventilation of her lungs with a bag and mask. Fortunately, the passage of an LMA secured a clear airway for controlled ventilation and anaesthesia until the tracheostomy tube could be reinserted in theatre. Subsequently, the patient made a full recovery and the tracheostomy was allowed to close.

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*The laryngeal mask is available from Colgate Medical Ltd, 1 Fair Acres Estate, Dedworth Road, Windsor, Berks SL4 4LE.

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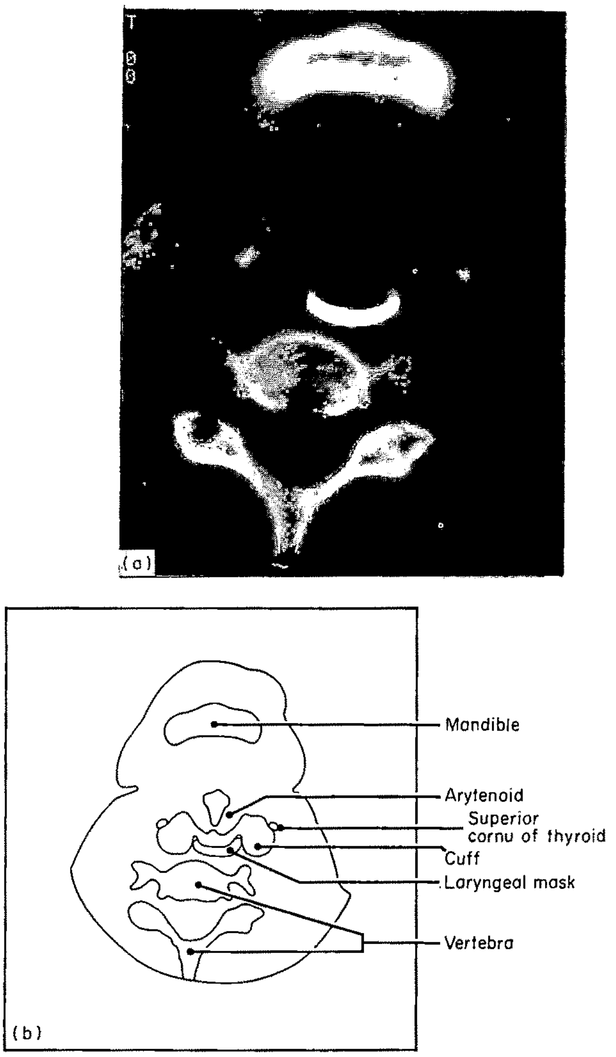

Fig. 1. (a) CT scan; transverse view of the LM *in situ*. (b) Line drawing of CT scan.

Discussion

It is essential, to ensure successful respiratory or cardiorespiratory resuscitation, that the airway is secured rapidly and effectively, so that positive pressure ventilation of the lungs is possible. This is commonly achieved by tracheal intubation, but this is not always easy.[8] Those who are not anaesthetists often find the procedure difficult and even an expert fails with some patients. Patients with poor mouth opening, limitation of movement at the atlanto-occipital joint and of the cervical spine are often a problem but even apparently normal patients can prove very difficult to intubate.[9] In addition, laryngoscopy and tracheal intubation have their own morbidity and mortality.[10]

Insertion of the LMA is simple, and the width of the LMA makes oesophageal misplacement unlikely. The CT scans (Figs 1 and 2) show the way in which the LMA 'cups' the laryngeal opening and also how 'downfolding' of the epiglottis can sometimes occur. A surprisingly good seal is obtained, but the ability of the mask to prevent contamination of the airway with regurgitated material is uncertain. Brodrick and his colleagues[11] reported their experience in 100 patients. Anaesthetists of all grades were given minimal training before they were required to pass the LMA. A satisfactory airway for spontaneous or controlled ventilation was obtained in 98 patients. The leak pressure around the cuff of the LMA was found to average only 1.7 kPa, but this would be insufficient if pulmonary compliance was reduced. The success of Brodrick's untrained colleagues, despite their inexperience with LMA, suggests that the device would be suitable for use by anyone trained in cardiopulmonary resuscitation. Damage to the patient's tissues by the LMA is unlikely because of its blunt, semi-rigid construction.

Brain's second suggested use for the LMA, as an alternative to tracheal intubation when conventional laryngoscopy and tracheal intubation proves impossible, was recently also given support.[12] We have had opportunities to use the

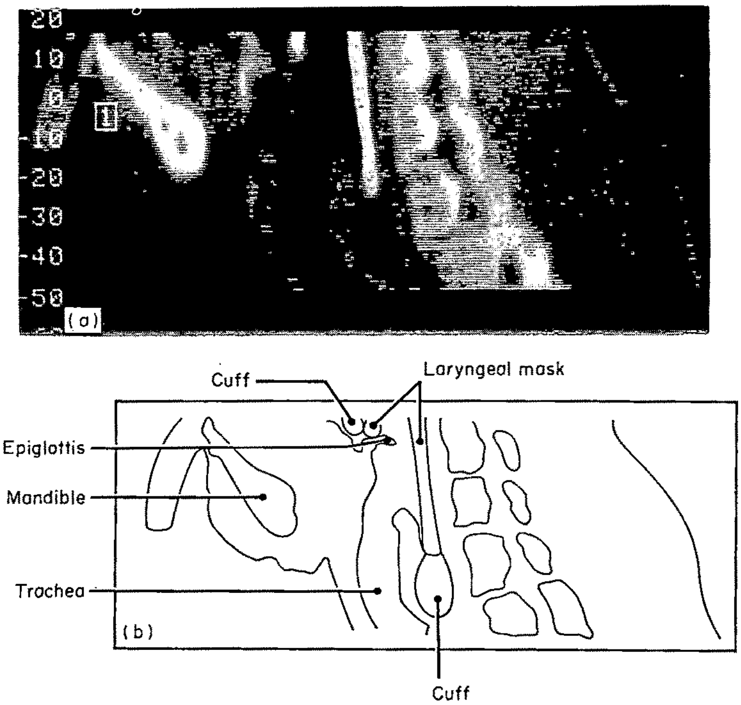

Fig. 2. (a) Scan; sagittal view of the LM *in situ*. (b) Line drawing of CT scan.

LMA as an anaesthetic airway in patients with severe cervical pathology and can recommend it for such patients and as an aid to fibreoptic intubation.

Brain suggested some years ago that his laryngeal mask could be used as an emergency airway[3] and compared his device favourably with the oesophageal obturator[13] airway which was designed for emergency use by paramedics in the United States. Problems associated with the obturator airway include the need to flex the neck to facilitate its insertion, a manoeuvre which may be undesirable or difficult where there is cervical pathology. Our experience supports Brain's proposal for the use of his airway in emergency resuscitation. We suggest the inclusion of the LMA in apparatus provided for resuscitation both within and without the hospital setting.

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Anaesthesia, 1990, Volume 45, pages 140–142

CASE REPORT

Hypotension due to unexpected cardiac tamponade

A. M. CYNA, R. C. RODGERS AND H. McFARLANE

Summary

We report a case of profound hypotension, after induction of general anaesthesia, that resulted from unexpected cardiac tamponade. The differential diagnosis was complicated by the absence of any evidence to indicate that there was significant direct chest injury. Many of the recognised clinical signs of cardiac tamponade were absent, in particular, there was no compensatory tachycardia, and heart rate remained stable despite severe hypotension before surgical drainage of the pericardium. The possible aetiology and pathophysiology is discussed. It is suggested that after major trauma, cardiac tamponade should be considered as a possibility even in the absence of significantly abnormal cardiovascular signs, evidence of direct chest injury, or an abnormal chest X ray.

Key words

Complications; cardiac tamponade, bradycardia.

Case history

A 25-year-old male student was admitted as an emergency after transfer by mountain rescue RAF helicopter over a distance of 60 miles. He had fallen some 30 metres on to scree while hill-walking in the Scottish Highlands.

He was pale in appearance, drowsy but conscious and orientated, on arrival in the Accident and Emergency Department. He gave a history of a few seconds loss of consciousness but no retrograde amnesia. On examination, there were multiple superficial abrasions over legs, buttocks, chest, back, arms and face, and a large haematoma over his forehead with a laceration at the hair line. His back was tender over the upper lumbar vertebrae and there was a compound fracture dislocation of the right elbow. Sternal tenderness was noted but rib springing was pain free. Pupils were equal and reacting to light and there were no focal neurological signs. His core temperature was 32°C increasing to 35°C, and his arterial blood pressure was 90 mmHg systolic on admission. For this reason he had received 400 ml of plasma protein solution and 1 unit of SAG-M blood. These had been administered into a central vein cannula inserted via a low right supraclavicular approach. Arterial blood pressure was subsequently recorded as 120/56 mmHg, and pulse as 80/minute, sinus rhythm. Air entry on chest auscultation was equal on both sides with no added sounds. Abdominal palpation revealed neither tenderness nor distension.

Chest and skull X rays were normal in appearance but abdominal films showed evidence of ileus, as well as some free peritoneal fluid. Dorsal spine X ray revealed a compression wedge fracture of the body of the first lumbar vertebra. A right elbow dislocation and separated fracture of the medial epicondyle were noted.

White cell count was raised at 42.5×10^9/litre, haemoglobin was 120 g/litre, platelets 400×10^9/litre. Electrolytes were normal and the urea was 8.7 mmol/litre. Arterial blood gas analysis (F_{IO_2}, 0.5) showed a pH of 7.11, P_{CO_2} 6.3 kPa, P_{O_2} 24 kPa, and a base deficit of 13.5 mmol/litre.

The orthopaedic surgeons wished to proceed with internal fixation urgently, in view of the compound dislocation fracture of the elbow, accompanied by lavage and dressing of the various lacerations and abrasions. Arrangements for theatre were made, since the patient was apparently stable.

Peripheral venous access was established with an intravenous 16-gauge cannula inserted into a left forearm vein, after arrival in the anaesthetic room. Blood was already being given slowly via the internal jugular cannula. Anaesthesia was induced, after 5 minutes pre-oxygenation, with intravenous alfentanyl 1 mg, thiopentone 150 mg and suxamethonium 100 mg, and cricoid pressure was applied. A 9-mm cuffed oral tracheal tube was inserted and the lungs were ventilated using a Manley Pulmovent ventilator, set to deliver a minute volume of 9 litres of 50% nitrous oxide in oxygen with isoflurane 0.5–1%.

The pulse became thready and barely palpable, immediately after induction, although the ECG was unchanged in both the shape of complexes and rate, which was 80/minute. The patient was quickly transferred to theatre

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where additional monitors, a capnometer and automatic arterial blood pressure apparatus were attached. Systolic arterial pressure was 40 mmHg and there was no measurable end-tidal CO_2. ECG complexes were normal and the heart rate of 80/minute remained unchanged. Oxygen 100% was administered, isoflurane maintained at 0.5%, and 1.5 litres of plasma protein solution given rapidly through the peripheral line. The patient was placed in a steep Trendelenburg position. Systolic arterial blood pressure became undetectable. Auscultation of the chest found heart sounds to be present but muffled. Chest expansion was equal on both sides and there was good bilateral air entry with no evidence of bronchospasm. Inflation pressures of 2.1 kPa were unchanged, and the abdomen remained undistended. There was no cutaneous manifestation of allergy.

Incremental intravenous doses of 2 mg methoxamine to a total dose of 20 mg increased arterial blood pressure to 77/36 mmHg with an ECG rate of 92/minute. End-tidal CO_2 readings were by now measurable but low. Attempts to aspirate the supraclavicular line were unsuccessful and a new 8.5-G central venous catheter (Arrow introducer-sheath) was inserted via the right internal jugular vein. Central venous pressure, as measured from this catheter at the level of the mid-axillary line, was 18 cm H_2O and a diagnosis of cardiac tamponade was suspected. A peroperative chest X ray showed no obvious abnormality. An attempt at subxiphoid pericardiocentesis was made with aspiration of 12 ml of dark blood. A dopamine infusion was started at 20 μg/kg/minute and the base deficit of 11 mmol/litre was corrected with 150 ml of 8.4% sodium bicarbonate. Ten ml of calcium chloride 10% was also given. These measures resulted in a transient increase in the arterial blood pressure to 135/64 mmHg but this decreased to less than 90 mmHg systolic within the next 2–3 minutes. The heart rate remained steady at 76/minute. The cardiothoracic surgeon performed an upper midline laparotomy which revealed no abnormality. The diaphragm was then opened to reveal a bulging inferior pericardium. There was a gush of 200 ml of dark blood and clot, when the pericardium was incised. This was followed by an immediate increase in arterial blood pressure, which reached a maximum of 156/80 mmHg over the next 5 minutes. There was a marked decrease in airway pressure from 2.1 kPa to 1.0 kPa while expired tidal volume remained unchanged at 750 ml. The central venous pressure remained somewhat high at 12–15 cm H_2O. Median sternotomy failed to reveal any source of the pericardial blood from aorta, atria or ventricles which were all fully inspected.

Anaesthesia was continued with nitrous oxide, oxygen and isoflurane, while increments of 2 mg vecuronium after a 6-mg bolus maintained muscle relaxation. Fentanyl 200 μg was given intravenously for analgesia after release of tamponade. The blocked supraclavicular line was removed at the end of surgery. This was found to be a 23-cm long Vygon Desilet vascular dilator attached to an intravenous giving set via a three-way tap at its proximal end. The dopamine infusion rate was decreased to 5 μg/kg/minute. Five units of packed cells and a further 3 litres of plasma protein solution were infused over the 2-hour operating time. Total operative blood loss was 1000 ml. Arterial blood pressure on transfer from theatre to the intensive care unit was 112/70 mmHg with a heart rate of 97/minute.

The postoperative course after 24 hours ventilation of the lungs was relatively uneventful. Arterial blood pressure remained at approximately 140/60 mmHg with a heart rate of 100–110/minute in sinus rhythm. The mean central venous pressure remained stable at 6 cm H_2O. Chest X rays showed some right upper lobe collapse with partial re-expansion after 72 hours. Slight tricuspid valve prolapse was seen on echocardiogram on the third postoperative day with no evidence of right ventricular volume overload. There was also a 1 cm posterior pericardial effusion, but no evidence of compression. The patient was discharged from the intensive care unit after 5 days. There appeared to be no neurological or other sequelae, apart from a complete loss of memory of events after the moment of his accident.

Discussion

Cardiac tamponade is a complication of pericardial effusion and occurs when pericardial pressure is high enough to interfere with ventricular filling. The volume of fluid required to cause cardiac compression varies considerably. If it has collected slowly 1–2 litres may be present. However, with rapid collections of fluid within the pericardium, very much smaller volumes may lead to cardiac tamponade,[1] which is characterised by a reduction in diastolic filling of the ventricles, decreased stroke volume, and lowered arterial blood pressure.[2] This increased intrapericardial pressure is exerted equally on all the chambers of the heart, to result in the equilibration of intrapericardial, right atrial, right ventricular diastolic, left atrial, and left ventricular diastolic pressures. The stroke volume of both ventricles is reduced because of the reduced diastolic volume in each ventricle. Decreased stroke volume usually results in sympathetic nervous system activation (tachycardia, vasoconstriction) in the attempt to maintain cardiac output; this is maintained as long as the central venous pressure is above right ventricular end-diastolic pressure.[3]

There were initially no abnormal clinical signs in our patient apart from the profound hypotension after induction. There was in particular no compensatory tachycardia in this previously fit young man. This absence of tachycardia may be the result of a decrease in diastolic volume which mimics that of profound hypovolaemia. Sensory receptors in the left ventricle are activated during an acute reduction in blood volume.[4] This signal from the heart appears to obtund the compensatory baroreflex mechanism via endogenous opiate receptors (governed by delta receptors) located in the ventricles of the brain.[5] Patients who are hypotensive from acute blood loss may develop a relative bradycardia, and transfusion not only restores arterial blood pressure but also causes an increase in the heart rate.[6] This suggests that once blood volume (and thus left ventricular end-diastolic volume) is restored to a critical level the cardiovascular responses are switched on again.[7] Bradycardia is observed during acute tamponade and severe haemorrhage in dogs anaesthetised with pentobarbitone, despite bilateral cervical vagotomy, sympathectomy, and intravenous atropine. It was suggested that sinoatrial node ischaemia was the cause of the shift of the pacemaker and resultant bradycardia in both cardiac tamponade and severe hypovolemia.[8] Indeed bradycardia may be protective because it prevents myocardial damage by allowing improved ventricular filling when preload decreases.[9]

General anaesthesia and controlled ventilation can lead to profound hypotension as a result of decreased venous return, peripheral vasodilatation and direct myocardial depression,[2] especially in association with unrecognised hypovolaemia. However, this patient appeared clinically to be adequately resuscitated before induction. Other possible causes of hypotension, such as sudden concealed haemorrhage, pneumothorax and allergy were considered but not confirmed by clinical signs. Tachycardia and pulsus paradoxus (> 10 mmHg), are well recognised early signs of cardiac tamponade, neither of which was evident at any stage in this patient. The central venous line was used for vascular access alone, and no measurements of venous pressure were made pre-operatively. This might have suggested the diagnosis.

Acute cardiac tamponade may follow both blunt and sharp chest trauma and may result in unexpected clinical effects.[10] Compression wedge fracture of the body of L_1 suggested major trauma, in the case described, and in retrospect other occult injury should have been suspected, in particular blunt chest trauma. Some sternal tenderness was noted before operation, but this was not considered to be significant and sternal fracture was not checked for on lateral X ray views. SAG-M blood was administered into a central venous 'cannula'. This was inserted via a low right supraclavicular approach which may have produced traumatic entry into the mediastinum, although the source of the intrapericardial blood was not confirmed at operation.

Perhaps the most important factor in early diagnosis of cardiac tamponade during anaesthesia is a high index of suspicion, since there are no specific physical signs. Indeed, any or all of the common features (elevated jugular venous pulse, tachycardia, pulsus paradoxus, pulse pressure < 30 mmHg, systolic arterial blood pressure < 100 mmHg, friction rub, Kussmaul's sign, decreased heart sounds) may be absent.[11]

We believe that any patient who has suffered major trauma may have occult chest damage. It is suggested that cardiac tamponade should be considered as a possibility even in the absence of significantly abnormal cardiovascular signs, evidence of direct chest injury, or an abnormal chest X ray.

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Anaesthesia, 1990, Volume 45, pages 143–144

CASE REPORT

Continuous brachial plexus blockade

A technique that uses an axillary catheter to allow successful skin grafting

B. RANDALLS

Summary

An 82-year-old woman sustained a full thickness burn of her hand. A technique for producing anaesthesia of the brachial plexus via an indwelling catheter is described. Confirmation of the catheter position was obtained by X ray. Bupivacaine was infused via the catheter after operation to produce immobilisation of the hand to ensure multiple skin grafts would take. Consequent with this goal was excellent postoperative analgesia.

Key words

Anaesthetic technique, regional; brachial plexus block.
Analgesia; postoperative.

Continuous brachial plexus blockade has been practised since 1969, usually for prolonged surgical procedures or postoperative pain relief.[1–3] Various techniques for entering the nerve sheath that surrounds the brachial plexus have been described.[4–5] This report describes a technique for insertion of an epidural catheter into the axillary sheath to provide prolonged anaesthesia to immobilise the hand.

Case history

An 82-year-old, blind diabetic woman (controlled on glibenclamide 5 mg daily) accidentally burnt her hand with boiling water, which resulted in a full thickness burn below the wrist. This was initially debrided under general anaesthesia. Analgesia postoperatively was provided by pethidine 75 mg intramuscularly 3 hourly.

Skin grafting was performed 2 days later. An axillary plexus block was performed using the immobile needle technique,[4] and 30 ml of 1% mepivacaine was injected. A femoral nerve block using 10 ml of 1% mepivacaine with 1:200 000 adrenaline was also performed to allow a skin graft to be taken from the thigh. No sedation was given and oxygen was administered via an MC mask at 2 litres/minute.

The surgeon requested that motor blockade of the hand be maintained after the procedure to prevent finger movement and allow the skin graft to take. It was not feasible to elicit parasthesiae or motor nerve stimulation with a nerve stimulator because intense motor and sensory blockade was already present. It was decided to insert a catheter using the transarterial approach.[5]

An 18-gauge cannula was used to puncture the axillary artery high in the axilla. The needle was slowly withdrawn until no blood flowed back. The plastic cannula was pushed off the needle, and 5 ml of saline injected to dilate the axillary sheath. A 19-gauge closed tip epidural catheter with side holes (Periflex) was threaded through the cannula and into the axillary sheath for 4 cm. The cannula was removed and the catheter secured. The position was confirmed by X ray after an injection of 3 ml of Niopam contrast medium (Fig. 1).

Bupivacaine 0.5% plain was injected through the catheter until full motor blockade was achieved (24 ml over 60 minutes). An infusion of 0.5% bupivacaine plain was commenced at 3 ml/hour[6] and continued for 120 hours. Throughout this time a sensory block from C_5–T_1 was maintained. She was able to abduct her arm to 20° but otherwise motor blockade was complete. There was no evidence of tachyphylaxis. The patient had a further grafting procedure performed 2 days after the initial skin graft. No supplementation of the block was required. She obtained excellent pain relief that required no narcotic analgesics. Full motor power and sensation returned within 12 hours after the infusion was stopped. There were no obvious short-term neurological sequelae or axillary infection. Follow-up at 6 months was similar and graft coverage was good.

Discussion

There have been reports in the literature utilising continuous brachial plexus block for surgical anaesthesia,[1] for postoperative analgesia,[6] for arterial vasospasm[2] and for traumatic amputation.[7] The present report describes con-

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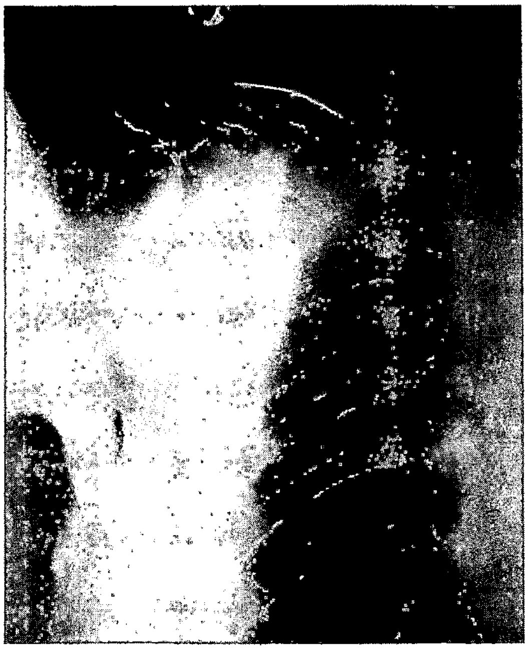

Fig. 1. Chest X ray that shows dye outlining brachial plexus sheath.

tinuous brachial plexus blockade for motor blockade of the arm to allow skin graft to take. Consequent with the block was prolonged excellent analgesia and a sympathetic block improving limb blood flow.[2,8] An interscalene block was considered as another route of continuous analgesia, but was discarded since block of the lower routes of the plexus (i.e. the ulnar nerve) cannot be guaranteed[4] and in this case complete motor block was essential.

It was not possible to measure bupivacaine levels, but two previous studies[6,9] showed levels below 2 μg/ml for continuous interscalene block using an infusion rate of 0.1 mg/kg/hour[6] and below 1.8 μg/ml for continuous axillary block[9] using 25 mg/hour. Catheters have been left in the axillary plexus for up to 9 days.[3] However, in that study, injections were only given intermittently to provide 'transient analgesia' for physiotherapy. Here analgesia was maintained for 5 days.

The technique described guarantees entry into the axillary sheath even in the presence of a pre-existing motor block, but there is a risk of haematoma formation or vasospasm.[10] Using the adaptation of Hansen *et al.*[9] it would be possible to place the catheter without entering the axillary artery. The use of a catheter in the axillary sheath has several advantages. It should allow an increased success rate of the block and avoid the risk of intravascular injection. It will allow the block to be topped-up during prolonged surgical procedures, and the infusion of local anaesthetic to give excellent postoperative analgesia.

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APPARATUS

Equipment deadspace and drug administration

A. G. MACFIE

Summary

Equipment deadspace can be a hazard in drug administration. The aim of this study was to measure the size of this problem. The deadspaces of a selection of cannulae, syringes and epidural catheters were measured by displacing the deadspace volume with water and measuring the weight gain. Between 10 and 30% of a 1-ml intravenous dose will remain in the deadspace depending on the type and gauge of the cannulae. The deadspace of an epidural catheter and filter is approximately 1 ml. All cannulae should be flushed after drug administration. Epidural catheters must be flushed with the same solution as the test dose before insertion.

Key words

Equipment; deadspace, drug administration.

Equipment deadspace can lead to the delivery of an inadequate dose of drug and result in a poor response. The drug that remains in the deadspace may later be delivered to the patient when the cannula or catheter is next used. Small volumes of drug may have suprisingly large effects.

The deadspaces of various types and gauges of cannulae, syringes and epidural catheters were measured to quantify this problem. The selection is not comprehensive and has been restricted to the types in common use in local hospitals.

Methods

A Metter AE163 electronic balance was used to weigh the cannulae and the catheters before and after the deadspace was filled with sterile water. The reproducibility of the balance has a standard deviation of 0.02 mg and was calibrated before use. The equipment to be tested was placed in a 25-ml beaker on the balance and the balance was then zeroed. The cannula was flushed with sterile water in a standardised manner from a 5-ml syringe and replaced on the balance. This process was repeated for each item tested. Ten cannulae of each type were tested. One millilitre of sterile water was taken to weigh 1 g at room temperature. To simulate the clinical setting and allow for fair comparison, the portless cannulae (Jelco) were filled through a 21-gauge BD Microlance needle and a Vygon injection bung. Therefore, the deadspace is a total deadspace of cannula, bung and needle.

The syringe deadspace was measured in a similar way. The weight gain of each syringe, which had been drawn up to capacity with sterile water and then ejected, was measured. All air bubbles were evacuated wherever possible. The deadspaces of both 16- and 18-gauge epidural catheters and filters (Portex Minipack System 1) were measured using the same technique. The weight difference of five catheters and filters of each gauge was measured after flushing with sterile water. Statistical analysis was performed using the Student's *t*-test. A p value of 0.05 was taken to be significant.

Results

The deadspace of a selection of cannulae and indwelling needles are presented in Table 1. Results showed a significant increase in deadspace with cannula gauge. Cannulae of equal gauges with injection ports (Venflons) had a significantly smaller deadspace than the combination of Jelco cannulae, Vygon injection bungs and a 21-gauge BD Microlance needle.

The deadspaces of cannulae are not generally available as part of the product information. Most indwelling needles do quote tubing volumes and the Venisystems' 21-G Butterfly has a tubing volume of 0.4 ml which is different from the 0.3 ml measured in this study. This is probably because in this study the deadspace volume was measured with the screw cap back in place after flushing; therefore the measured deadspace would be smaller than the total tubing volume.

Table 2 shows the deadspaces of various sizes of syringe. The volume is also expressed as a per cent of the total syringe volume. This volume rose to 2.35% in the smaller 2-ml syringes. Table 3 shows the deadspaces of both 16- and 18-gauge epidural catheters and filters in combination.

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Table 1. The deadspace (ml) of a selection of intravenous cannulae and indwelling needles. Values are expressed as mean (SD).

Cannulae SWG	Deadspace $n = 10$
Viggo	
Venflon (2)	
22	0.106 (0.008)
18	0.140 (0.004)
14	0.224 (0.005)
Wallace Y-Can* 21	0.191 (0.010)
Venisystems	
Butterfly 21	0.309 (0.021)
Jelco* 22	0.165 (0.022)
18	0.206 (0.024)
14	0.301 (0.038)

*The Wallace Y-Can was tested attached to 21 BD needle. The Jelco cannulae were tested in combination with a Vygon injection bung and a 21 BD Microlance needle.

Table 2. The deadspace (ml) of a several sizes of syringe. Values are expressed as mean (SD).

Type of syringe	Deadspace $n = 10$	% of total volume
BD Plastipack		
2 ml	0.047 (0.0028)	2.35
5 ml	0.055 (0.0047)	1.10
10 ml	0.067 (0.0034)	0.67
20 ml	0.078 (0.0070)	0.39

Table 3. The deadspace (ml) of epidural catheters and filters. Values are expressed as mean (SD).

Epidural catheter	Deadspace $n = 5$
Portex Minipack	
System 1	
Flat filter +	
Catheter 16 G	1.053 (0.04)
Catheter 18 G	0.965 (0.04)

Both sizes had deadspaces of approximately 1 ml but which were statistically different although the sample size was small. It was found to be important to twist the injection bungs tightly home or the deadspace could be considerably increased. Other sources of variation came from the variable size of the droplet at the end of the cannula or needle and the variation in the size of the cannulae themselves.

Discussion

The results of this study show that between 10 and 30% of a 1-ml intravenous injection may remain in the deadspace of the cannula or indwelling needle depending on the type and gauge. This volume of deadspace may represent a relatively larger dose of drug in paediatric practice. The deadspace becomes of increased importance when intravenous injections are of high potency and low volume.

The lost drug may result in the delivery of an inadequate dose. A 1-ml ampoule of the new 'Robinul–Neostigmine' (A.H. Robbins) contains 2.5 mg neostigmine and 0.5 mg glycopyrronium. Robinul–Neostigmine has gained popularity because of ease of administration of the convenient single ampoule for reversal of neuromuscular blockade. However, a significant volume of this 1-ml dose may remain in the cannula deadspace and possibly result in inadequate reversal of neuromuscular blockade. Other drugs that are prepared in 1-ml ampoules include atropine, morphine, papaveretum, ephedrine, and adrenaline.

The retained drug may be flushed into the circulation when the cannula is next used. Small doses of muscle relaxants may have surprisingly large effects. A 21-gauge butterfly contains approximately 0.3 ml or 15 mg suxamethonium. There is considerable variability in response to suxamethonium[1] and a dose of 5 mg has caused complete paralysis in an individual with normal plasma cholinesterase.[2]

The retained dose of vecuronium in its standard concentration of 2 mg/ml in a butterfly is approximately 0.6 mg. This is equivalent to a dose of 0.01 mg/kg in a 60-kg patient. In awake volunteers 0.01 mg/kg of vecuronium caused a small but significant depression of the train-of-four ratio (TOF) with a median value of 0.86 and a range of 0.76–0.94. This caused heavy eyelids, blurred vision and signs of ptosis in most of the patients. The increased dose of 0.015 mg/kg caused a reduction of the TOF to 0.64 (0.57–0.82). One patient in this study received only 0.3 mg vecuronium; his breathing became very shallow and he was unable to move. The single twitch height was decreased to 25%.[3] The effect of this size of dose may be more pronounced in a partially reversed patient.

The deadspace of epidural catheters and filters may result in ineffective test doses being used. The ideal test dose after epidural catheter placement must determine within 2 minutes that the catheter is not placed intravascularly or in the subarachnoid space. Moore and Batra suggested this should take the form of 3 ml of local anaesthetic and 0.015 mg adrenaline.[4] More recently, because of the occurrence of unacceptably high blocks when 3 ml 0.5% bupivacaine is given spinally,[5] it has been suggested that 1.5 ml of 0.5% bupivacaine and 1:100 000 adrenaline would be a more appropriate test dose. This study shows that the average deadspace of a 16-G Portex epidural catheter and flat filter is approximately 1 ml. It is essential, if a test dose of 1.5 ml volume is used, that the catheter be flushed with the same solution before use. The ampoule of 1.5 ml 0.5% bupivacaine with 1:100 000 adrenaline which Kumar suggested, would have insufficient volume to flush the catheter and deliver 1.5 ml.[6]

The problems of intravenous deadspace could be avoided if all drugs were given into a running infusion. An added benefit would be the reduction in drug reactions that result from mixing of incompatible drugs in the cannula deadspace. It has been suggested that the mixing and precipitation of thiopentone and atracurium, which occurs when injected through the same cannula without a saline flush, may initiate systemic aggregate anaphylaxis.[7] A cheaper alternative is for all cannulae to be flushed with saline as routine after drug administration.

Dilution of drugs may minimise the problem in some cases; however, this may lead to errors. Only 58% of anaesthetists were able to dilute drugs within 10% of target concentrations under test conditions.[8] Perhaps pharmaceutical companies should prepare drugs designed to be administered intravenously in more dilute concentrations and larger volumes.

Anaesthetists should be aware of the potential problems associated with equipment deadspace and drug administration.

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SPECIAL ARTICLE

Unexpectedly extensive conduction blocks in obstetric epidural analgesia

B. MORGAN

Summary

Life-threatening extensions of conduction block during obstetric epidural analgesia can be classified according to the risk to the mother. High blocks that occur in the presence of the anaesthetist should present a readily treatable problem. Reports of total spinal anaesthesia that occur with no anaesthetist in attendance call for a reappraisal of present practice. Changes in current anaesthetic practice, which might increase safety with epidural analgesia, are top-ups by midwives, but only when the anaesthetist is on the delivery suite; repeated assessment of the nature of the conduction block by an anaesthetist; and continuous infusions with anaesthetist-only top-ups.

Key words

Anaesthesia; obstetric.
Anaesthetic techniques, regional; epidural.

Surveys of current obstetric anaesthetic practice in the UK reveal a wide disparity of standards of supervision for mothers who receive epidural pain relief in labour.[1–3] Early confidence in the technique suggested that complete safety could be assured if the anaesthetist who established the block stayed at least 10 minutes with the mother to ensure a satisfactory block and absence of hypotension; all subsequent top-ups could then be performed by the appropriately trained midwife. The anaesthetist had no need to see the patient again unless called by the midwife because of inadequate analgesia or hypotension. This level of care is no longer considered sufficient in many units because of experiences with epidural complications.

The degree of attention the anaesthetist gave to the obstetric patient with epidural analgesia is shown in a survey of practice in a single health region.[1] In 81% of units the top-ups were given by the midwife in the first stage of labour and in 68% in the second stage as well. The anaesthetist returned frequently to see the patient in 59% of units and sometimes, or only when called, in the rest.

The report on Confidential Enquiries into Maternal Deaths 1976–78[4] states that the technique is unsafe unless the anaesthetist is immediately available to attend to the mother. This, the report suggests, is not a counsel of perfection but merely provides a level of anaesthetic care for the obstetric patient that is regarded as essential in surgical practice. Ten per cent of the 137 obstetric units in the UK in 1986 with a 24-hour epidural on-demand service had no anaesthetist on the premises during the day, in spite of this recommendation. This was increased to 23% at night.[3]

The Standing Advisory Committee of the Royal College of Obstetricians and Gynaecologists on obstetric anaesthesia has stated that 'epidural analgesia should not be used unless a person capable of cardiopulmonary resuscitation of the pregnant woman was present on the labour ward'. This recommendation has been incorporated into the general professional training guide of the College of Anaesthetists.[5]

Surveys of epidural complications, as well as anecdotal reports, all reveal unexpectedly extensive blocks.[6–8] The incidence is low in these reports although the actual rate can only be ascertained in a prospective country-wide survey now planned through the Obstetric Anaesthetists' Association. Published case reports almost always involve a successful outcome. Maternal deaths in England and Wales are detailed and published, but where the result has been anoxic damage to mother or child, fear of litigation prevents publication of details. This failure to publish may increase complacency about the safety of unsupervised epidural analgesia.

A suggested classification of unexpectedly extensive blocks that have been reported mainly in obstetric patients is shown in Table 1.

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Table 1. Classification of unexpected extensive conduction blocks.

1. High or total spinal on first therapeutic dose.
   Subarachnoid injection after false negative aspiration and test dose.
   Subdural block — 'Massive epidural'.
2. Increased risk of high block on subsequent top-up.
   After known prior dural tap.
3. High or total spinal on subsequent top-up.
   The migrating catheter.

Unexpected spinal block on first therapeutic dose. False negative aspiration and test dose

Failure of the technique to reveal reliably the presence of the catheter in the subarachnoid space is so well known that the use of test doses is widespread. However, total or high spinal anaesthesia is consistently reported on the first dose in spite of negative aspiration and test dose.[9–16]

The usual sequence in these patients is the onset from 90 seconds to 20 minutes of dyspnoea, hypotension, unconsciousness and apnoea, after the first whole dose. The condition is dramatic, easily recognised and treated provided there is immediate access to intubation and ventilation equipment. The anaesthetist is commonly aware of the possibility of this serious complication. A recent survey of a single regional health authority revealed that in most units the anaesthetist remained with the mother for more than 10 minutes after epidural injection.[1] Neither mother nor fetus should come to harm as a result of this serious complication, if ventilation, cardiovascular support and lack of aortocaval compression are assured by the anaesthetist who is present with the mother at the time.

Subdural blocks

There are several reports that the catheter may be placed in the subdural space confirmed by X ray[17–20] and suspected but not proven in other cases.[21–24]

The sequence of events in these blocks is that the onset to maximal block ranges from 20–30 minutes. Motor block is minimal or absent, hypotension is minimal and easily treated. The block extends unexpectedly high cranially but the retention of sacral sensation distinguishes it from a spinal block. It can, with a large dose, cause unconsciousness and apnoea since the subdural space extends intracranially, unlike the epidural space.[25] The block can be extensive unilaterally with modest sensory levels on the contralateral side.[18,19] This appears to be the same complication as that described by Massey Dawkins as the massive epidural.[6]

It can be difficult to distinguish this block from a subarachnoid block since there may be features in common. The main characteristics of a subarachnoid block that are usually present are the rapid onset of dense motor block often before any sympathetic block can be detected, hypotension, complete lack of sacral sensation and usually loss of proprioception. The speed of onset of the subarachnoid block, although not always its complete extension, is rapid and hypotension is often severe and also rapid. The block and its extent depends on the drug, the concentration and the volume, the speed of injection and the posture of the mother. It was found, in a series of 100 intentional total spinals in nonobstetric patients, that it can take up to 40 minutes for a subarachnoid injection to achieve the maximum block and produce a total spinal anaesthetic.[26]

High or total spinal block after a known prior inadvertent dural tap

Hellmann suggested that injection of local anaesthetic into the epidural space after an earlier, inadvertent dural tap might lead to total spinal anaesthesia and that epidural analgesia should be delayed for a week after a dural tap.[27] Lund considered that provided another site was used to place the epidural catheter no difficulty would result.[28] Kalas and Hehre,[29] however, suggested that the epidural catheter may be replaced even in the same space, and with careful 1-ml doses of epidural injected local anaesthetic drug, safety would be assured.

High or total spinals after previous known dural tap are reported after subsequent top-ups.[30–36] In these case reports extensive block may follow any top-up. The onset of the extensive and obviously subarachnoid block is often slow, with a range of 2–40 minutes after the top-up. Total spinal anaesthesia, as well as very high blocks, are described.

Prior dural tap with the epidural catheter placed in another intervertebral space may provide a route for transfer of the local anaesthetic into the subarachnoid space. The level of sensory loss is known to be higher in these patients than would be expected.[37] The epidural space becomes filled with CSF after prior dural puncture,[38–40] and possibly allows greater than normal access of the drug into the subarachnoid space as pressures become more equal. Other features that may increase the risk are rapid injection and large volumes of local anaesthetic, usually for operative delivery. The danger of this complication is the slow onset which might occur after the anaesthetist has left the mother or the mother the delivery suite. Three standard textbooks suggest slow administration of a smaller dose of local anaesthesia once prior dural puncture has occurred.[41–43] In the survey by Frank and her colleagues[1] 18% of units allowed midwife top-up after dural punctures; all the rest had anaesthetist-only top-ups for these at-risk mothers.

High or total spinal anaesthesia on subsequent top-ups

This is obviously the most dangerous complication that can occur where midwife top-ups are practised. The anaesthetist is often not present, sometimes not even in the same hospital building, often elsewhere in the hospital, and may be engaged in some other anaesthetic activity when the unexpected total spinal anaesthetic occurs. The complication is rare and most midwives are at best slow to diagnose the problem before anoxic damage occurs. These events on the second or subsequent top-up have been well reported,[44–47] and show blocks that range from T_3 to total spinals after any subsequent top-up. Onset of the high block is reported in a range from seconds to 15 minutes after a top-up.

These cases cause considerable confusion to anesthetists. The explanation for this seemingly mysterious complication was claimed to be migration of the catheter. It was thought that a catheter correctly placed in the epidural space could penetrate the dura and subarachnoid membrane because of the patient's movements. However, Hardy has shown that an epidural catheter is not able to pierce the dura postmortem.[48]

Epidural catheters move both in and out of the skin mark during labour.[49] This does not, however, indicate that the catheter can puncture the dura or a vein wall during the migration. It may be that movement of the soft tissue between the skin and epidural space is the explanation for this.[50] Abouleish and Goldstein[25] described a case where a single-hole catheter migrated from the epidural to the subdural space, although it is possible that this could have occurred where the dura but not the arachnoid had a 'nick' caused by the point of the Tuohy needle. Other reports that purport to show catheter migration often indicate that an undiagnosed dural puncture has occurred, possibly with the point of the needle with the epidural catheter correctly placed in the epidural space, a normal epidural block and subsequent spinal headache[51] or CSF on aspiration.

Scott[52] has offered an explanation and has shown this to be possible *in vitro*. The multihole catheter can be placed partly in the epidural and partly in the subarachnoid space so that an initial slow injection will cause the local anaesthetic to emerge from the proximal holes and result in an epidural block. A subsequent more rapid injection will also result in some solution emerging from the distal holes,[53] to result in a subarachnoid block. This has now been shown to occur clinically.[54]

The catheter that lies in both the epidural and subarachnoid space may cause a block after a top-up that has features of both an epidural and subarachnoid block; the extent of the spinal block will depend on the proportion of the dose that enters the CSF. The sensory block may, for instance, extend as expected to T_{10}, but with complete sacral sensory block and motor block that is unexpectedly intense for the analgesic dose of bupivacaine given; thus, the features of a saddle block and an epidural block could possibly be present. It is also possible that a different degree and extent of block may follow each top-up, depending possibly on the speed of the top-up injection and the relative pressures in the subarachnoid and epidural space. Sudden increase in the spinal component of the block may occur if the patient is moved,[35] or on a rapid injection of the top-up dose, or when the pressures in the subarachnoid and epidural space have approached equality, to allow easier access of injected bupivacaine into the spinal space.

Total spinal anaesthesia seems unlikely to occur during the course of an epidural block without previous signs of subarachnoid block. However, most case reports that describe an unexpected spinal anaesthetic during an epidural block give no details of the degree of motor paralysis and dermatomal sensory level beforehand. One assumes these were not elicited.

Discussion

Continuous epidural analgesia for postoperative pain in nonobstetric patients is usually only considered safe in the intensive care or high dependency unit where monitoring and immediate ventilatory support is available. Labour wards are frequently assumed to be similar to high dependency units. However, when unexpectedly high or total spinal anaesthesia occurs the midwife on her own or with the help of junior obstetric staff is often unable to diagnose the nature of the catastrophe, let alone institute treatment immediately. The very short period of complete apnoea that the pregnant woman, with her increased oxygen requirements, can withstand before damage to herself or her infant requires immediate diagnosis and treatment. Instant access to resuscitation equipment necessary for tracheal intubation and ventilation is also essential. A further and possible fatal delay can ensue if anaesthetic equipment is in the labour ward theatre at some distance from the mother's room.

The insistence that anaesthetists should perform top-up injections is believed to be responsible for the limited availability of epidural analgesia in labour. Attempts to increase the safety of midwife top-ups are continuously suggested. Midwives are required in some units to attempt to withdraw the plunger before injecting down the epidural catheter, but lack of CSF is insufficient proof of safety. The use of divided doses by midwives or even test doses are advised. Neither of these can be seen as safe since the midwife is usually unable to assess whether the block that results from the test dose is an epidural or spinal block. Repeated midwife testing of the degree of motor block[55] or level of sensory block[56] are advised. Substitution of midwives for anaesthetists was not the concept of the Central Midwives Board when they agreed to midwife top-up in 1972.

The discrete differences between an epidural block, a mixed epidural and a saddle block require considerably greater anaesthetic training than midwives usually receive. Conduction blocks produce a spectrum of neurological changes. The clinical features of an epidural block may be less characteristic after a few top-ups. A dense motor block may be present, sacral sensation may be lost and the sensory level may have increased in height from T_{10} to T_6; the duration of each dose of bupivacaine may be longer. Proprioception is not usually lost with epidural block. The picture of a spinal block that results from 0.25% bupivacaine in small volumes is not clear, although this is used as a test dose or as a fractionated dose. To distinguish the nature of the conduction block the anaesthetist has to grasp the entire clinical picture of physical signs and the history of the block, rather than attempt to diagnose the neurological condition on a single sign.

Changes in current epidural anaesthetic practice entail greater monitoring of the mother in labour with an epidural block. In addition to pulse rate and arterial blood pressure recordings that most midwives do, monitoring the block must be undertaken at frequent intervals, at least hourly, by the anaesthetist, throughout the anaesthetic. An epidural record form is necessary, to give details of epidural drug dosage and maintenance of the block. This will also allow detailed recording of the bilateral upper and lower sensory levels of block, the degree of motor block and the presence of sympathetic block and proprioception. Top-up bolus doses are marked in the manner of anaesthetic charts, and duration of action noted. These features will allow the anaesthetist to gain knowledge of the type of block present so that he (she) can detect a possible spinal component as a result of previous, perhaps undiagnosed, dural tap or a catheter partly in the epidural and partly in the subarachnoid space. It will also ensure an understanding of the reason for inadequate analgesia that might be present and this can then be corrected. It will also have important medicolegal implications. Topping-up slowly and in fractionated doses would appear sensible. This can be performed by the midwife only if the anaesthetist is present on the labour ward.

Infusion of dilute doses through the epidural catheter is also suggested as a safety measure to avoid the sudden changes that happen on top-up.[57] However, given that the same hazards are likely to exist, an undiagnosed hole in the dura, with the epidural catheter lying either wholly or partly in the epidural and partly in the subarachnoid or subdural space, might still cause problems. Infusions are likely to give similar complications once greater experience has been gained with them, but they may be a safer alternative because they require greater attention from the anaesthetist and dispense with midwife top-ups.

Cardiopulmonary resuscitation of the pregnant woman is known to have special problems of aortocaval compression,[58–62] but also because of unfamiliarity by the staff on labour suites. A regular programme of staff training has been suggested[63] to maintain ability in cardiopulmonary resuscitation of the pregnant woman.

Epidural block is now an essential part of obstetric practice for women with obstetric pathology; it is no longer only an optional analgesia available in normal labour at the request of some mothers in some units. It has shown itself to be remarkably safe. Even if rare, unexpectedly extensive blocks during the course of conduction anaesthesia can have sequelae as devastating as anoxia that occurs during any other form of anaesthesia.

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Forum

The nature of pre-operative anxiety

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Summary

In a study of 247 patients who had general anaesthesia for dental procedures, the incidence of individual anxieties was noted using a questionnaire completed by the patient. The most common anxieties related to the period before transfer to the operating theatre, intra-operative awareness and postoperative pain. These anxieties were present in over half the patients questioned. The follow-up questionnaire was completed by 207 patients in order to indicate which anxieties they would expect to have if they needed anaesthesia in the future. All anxieties were less frequent than found before operation.

Key words

Anaesthesia; dental.
Complications; anxiety.

The presence of anxiety is almost universal in the pre-operative patient. This anxiety is influenced by uncertainty about the impending procedure, by past experience of anaesthesia and surgery, and by suggestions of family, friends and fellow patients. The feeling is unpleasant, and may cause patients to fail to attend for the planned surgical procedure. In addition, presence of anxiety may complicate the induction of anaesthesia and alter the pharmacokinetics of the agents used by inducing catecholamine release, and indeed this release of catecholamines can be used as a measure of anxiety.[1]

Two main methods are used at present in an attempt to reduce the patient's anxiety. Firstly, a pre-operative visit, with reassurance and encouragement has been shown to reduce anxiety,[2] may reduce postoperative narcotic requirements and shorten hospital stay[3] and lead to a more prompt return to active life.[4] Detailed explanations given to the patient do not seem to reduce anxiety more than a relatively brief explanation.[5] Secondly, 'pharmacological' anxiolysis' with, for example, benzodiazepines or narcotics is used. It has recently been suggested that beta-adrenoceptor blockers may be used successfully in this respect.[6]

Pre-operative reassurance can only hope to be successful if it is appropriate, that the potential anxieties of the patient are discussed and that new anxieties are not introduced. To this end, it is important to know which features of hospital life and impending anaesthesia or surgery worry the patient. In addition, how does the experience of hospital admission and anaesthesia modify the patient's perceptions of these anxieties?

The aim of this study is to itemise the specific anxieties of patients admitted for routine anaesthesia and surgery, to determine the prevalence of these anxieties, and to see if the experience of anaesthesia modifies it.

Method

Two hundred and forty-seven ASA grade 1 and 2 patients admitted to hospital for routine dental extractions under general anaesthesia were interviewed. Their ages, sex and previous anaesthetic history were noted, along with the proposed surgical procedure. Patient characteristics are shown in Table 1.

One of the investigators introduced himself to the patients on admission and invited them to participate in the study. Their permission was obtained, and before any premedication or explanation of proposed anaesthetic or surgical technique was given, they were asked to complete a questionnaire and to indicate which, if any, of 10 pre-operative fears they were experiencing by marking a 'yes' or 'no' beside each fear as appropriate: these fears are listed in Table 2, and are expressed in terms which, it was hoped, patients of all intellectual abilities would understand. These 10 questions were used after a pilot study, in which patients were asked the open question of what worried them about the impending anaesthetic.

Patients received a benzodiazepine as premedication 1 to 1.5 hours before operation, and a standard inpatient dental anaesthetic with nasotracheal intubation after suxamethonium. The majority of patients had a narcotic analgesic administered intra-operatively.

Two hundred and seven of the patients were interviewed again the day after the operation. They were asked on this occasion, in view of their recent experience of anaesthesia,

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Table 1. Patient characteristics.

	Before operation	After operation
Males	107	91
Females	140	116
Age, years, mean (SD)		
Males	26.5 (9.8)	27.4 (10.4)
Females	24.2 (9.5)	24.6 (10.2)
No of teeth extracted range (median)		
Males	2 (1–10)	3 (1–10)
Females	2 (1–10)	2 (1–10)
% with previous anaesthetic		
Males	61	57
Females	53	54

what fears they would expect to have if they were admitted at any future date for a further anaesthetic. Fears were indicated by completion of a similar questionnaire as that before operation.

Results

Two hundred and forty-seven patients (107 male, 140 female) completed questionnaires before operation, and 207 of these (91 male, 116 female) completed the questionnaire again on the first postoperative day prior to discharge; the balance of 40 patients were not seen postoperatively due to service commitments of the investigators. No patient refused to complete the questionnaire, although two illiterate patients required help from nursing staff (who were not aware of the purpose of the study) to complete the form. All questionnaires were properly completed, and none had to be excluded from the study.

The results obtained from the patients seen pre-operatively are shown in Table 3, and those from the patients requestioned postoperatively are shown in Table 4.

Eight patients (six male, two female) claimed not to have any of the anxieties listed in the questionnaire pre-operatively; this increased to 18 (11 male, 7 female) postoperatively. No patient indicated that he or she suffered from all the anxieties listed, either before or after the procedure. Postoperatively 123 of the patients had fewer anxieties than noted pre-operatively, 49 had the same number and 35 had more.

Discussion

The pre-operative visit by the anaesthetist is usually the only opportunity that the patient has to discuss and receive explanation about the impending anaesthetic, and fears associated with it. The results of this study confirm that the vast majority of patients do have anxieties pre-operatively and many of these fears should be amenable to explanation. The results also demonstrate that the incidence of the listed anxieties is largely the same in both males and females, and this confirms the findings of others.[7] Frank discussion about potential fears does not upset patients[8] and may enable the patient to express anxieties which he or she had been embarrassed about raising.

Table 2. Points listed on patient questionnaire.

Pain after the operation
Not wakening up after the operation
Losing time off work or school
Not being asleep during the operation
Waiting to go to theatre for the operation
Not being able to sleep on the night before the operation
Injections and blood tests
Anaesthetic itself
Sickness or vomiting after the operation
Making a fool of yourself before, during, or after the anaesthetic

Table 3. Percentage of patients who expressed anxiety about listed fears before operation.

Fear*	Male	Female	Total
Pain after operation	55	66	65
Not awakening	29	39	34
Time off work	15	13	14
Not asleep during operation	43	63	54
Waiting for operation	44	61	53
Night before operation	18	27	21
Injections	32	36	34
Anaesthetic itself	14	36	26
Sickness/vomiting	41	54	48
Appearing foolish	30	39	36

*Abbreviation of fears listed in same order as in Table 2.

The most common fear pre-operatively relates to pain associated with the surgical procedure, and it is a poor reflection on our management of it, or alternatively of the patients expectations of it, that 50% of patients state that postoperative pain would worry them if they were readmitted for a similar procedure in the future. In association with this, the very frequent occurrence of anxiety about nausea and sickness would suggest that a more aggressive use of antiemetics may be needed, although the well known emetic effect of swallowed blood may be more important than the anaesthetic drugs used.

About half of all patients expressed concern that they would not be asleep during the operation. This fraction may be abnormally high, since much publicity has surrounded previous cases of awareness during the study, and in particular a local case of awareness that was highlighted in the local, national and specialty press.[9] It is evident, despite this, that much reassurance is required in this respect. Over one quarter of the patients were still worried about not being asleep during a future anaesthetic despite the fact that no cases of awareness occurred in any patient involved in the study.

The second most frequent pre-operative anxiety was about waiting to go to the operating theatre, and reassurance about anxiolytic premedication may help the patient to pass this time in a reasonable state of mind. Anxiety was still expressed by 41% about this problem if a future anaesthetic was needed, despite having received an anxiolytic premedication. It is common practice to administer

Table 4. Percentage of patients who expressed anxiety about listed fears after operation.

Fear*	Male	Female	Total
Pain after operation	41	59	50
Not awakening	25	16	21
Time off work	15	9	11
Not asleep during operation	23	31	28
Waiting for operation	36	46	41
Night before operation	9	24	17
Injections	22	28	27
Anaesthetic itself	12	21	17
Sickness/vomiting	34	52	43
Appearing foolish	22	29	28

*Abbreviation of fears listed in same order as in Table 2.

premedication at a fixed interval before surgery, but for the patient at the end of a long operating list, the increase in anxiety may well occur when his fellow patients leave the ward for the operating theatre, and perhaps the earlier administration of premedication may help.

Over one third of patients were worried about making a fool of themselves peri-operatively while under the influence of anaesthetic drugs. This loss of control by the patient may indeed occur on some occasions, and the patient waiting to go to the operating theatre may witness this in the ward as postoperative patients return, or indeed if the recovery area is used as a 'holding area' for pre-operative patients. It is important that this exposure of pre-operative patients should be kept to a minimum and patients reassured by the understanding of staff directly dealing with patients recovering from the effects of anaesthesia.

Many patients expressed concern that an anaesthetic facemask would be forced upon them at induction, and welcomed the news that an intravenous induction would be used. Conversely, a small number of patients with a 'needle phobia' requested a gaseous induction.

This study is designed to indicate which fears the pre-operative patient most commonly experiences. No attempt has been made to quantify the anxieties, since better methods than this questionnaire exist to do so, such as use of linear analogue scales,[10] catecholamine estimation,[1] use of scoring systems[11–13] and self-evaluation questionnaires.[14]

The pre-operative patient may benefit from the proper choice of premedicant, which can 'pave the way to a smooth anaesthetic and postoperative course',[15] and requires reassurance that postoperative pain and sickness will be adequately dealt with, that they will be asleep throughout the duration of the surgical procedure, and that they will waken up at the end of the surgery. Despite increasing commitments in the operating theatre, the intensive care unit and other areas, time must still be found for the pre-operative visit.

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Paediatric postoperative analgesia

A comparison of rectal diclofenac with caudal bupivacaine after inguinal herniotomy

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Summary

Forty-three children for day case inguinal herniotomy under general anaesthesia were assigned randomly to receive either 1 ml/kg caudal bupivacaine 0.25% or rectal diclofenac 0.25 mg/kg intra-operatively to provide postoperative analgesia. Pain and demeanour were assessed by an observer in the early postoperative period after operation and by questionnaire for the parents over the first 24 hours. Caudal bupivacaine provided more pain-free patients at first but later the incidence of pain was similar in the two treatment groups. Rectal diclofenac is a useful alternative to caudal blockade in this group of patients.

Key words

Anaesthetic techniques; epidural, caudal.
Analgesics; diclofenac.

Provision of pain relief after an operation is essential in day case surgery in children, not least to permit rapid discharge from hospital of a comfortable patient, who is free of complications, with parents who are reassured of their child's well-being in the immediate and later postoperative period. An analgesic regimen therefore has to be effective, but not a limitation to early mobilisation.[1]

Caudal analgesia is used successfully in the provision of pain relief after day case herniotomy in children, but occasionally it may result in adverse effects as a result of a more extensive block than is necessary.[2] Caudal blockade may relieve early postoperative pain, but in the later period systemic analgesia was shown to be superior.[3]

Recently, interest has arisen in the use of nonsteroidal anti-inflammatory drugs (NSAIDs) to provide postoperative analgesia. Intravenous indomethacin was employed and diclofenac was shown to be effective in the management of pain after tonsillectomy, by systemic administration in adults and by rectal administration in children.[4–6]

Rectal administration in children is a safe and convenient route of drug absorption and diclofenac is available commercially in a paediatric suppository formulation. Diclofenac is completely absorbed after rectal administration and the sustained action of the drug may provide analgesia in the early and late postoperative phases, whilst the respiratory depressant effects of conventional opioid analgesia are avoided.[7]

The purpose of this study was to compare rectal diclofenac with caudal bupivacaine for pain relief in children who have herniotomy as day cases.

Patients and methods

Children aged 1 to 10 years who presented for day case inguinal herniotomy were admitted to the study. Approval for the study protocol was obtained from the District Ethics Committee and informed written consent was obtained from the parent of each child.

No premedication was given. General anaesthesia was induced with either thiopentone 5 mg/kg via a 23-gauge winged needle in a dorsal vein on the hand, or by inhalation induction with nitrous oxide, oxygen and halothane according to age and preference. Anaesthesia was maintained with spontaneous ventilation of nitrous oxide 67%, oxygen 33% and halothane, delivered via a Bain coaxial system or Ayre's T-piece. Venous access was obtained after induction of anaesthesia, if not already established, and patients were randomised to receive either a caudal injection of 1 ml/kg plain bupivacaine 0.25% up to a maximum of 20 ml (group C), or a suppository of diclofenac 2.5 mg/kg (group D). These were commercially available 12.5-mg and 50-mg suppositories prepared by the hospital pharmacy. All anaesthetics, caudal blocks and suppository insertions were performed by the same anaesthetist (J.G.W.). The sacral hiatus was covered with a gauze swab in all patients to achieve observer blinding. Additional postoperative analgesia with papaveretum 0.2 mg/kg as well as paracetamol 120–500 mg was prescribed for each patient. No operation lasted more than 40 minutes.

Patients were assessed by a single independent observer 1, 2 and 4 hours after return to the ward. Pain was assessed by allocation to one of three categories: none/insignificant pain; moderate pain; or severe pain. Demeanour was assessed with reference to three categories: cheerful and calm; restless; or tense and tearful. The occurrence of side effects and requirement for additional analgesia were recorded.

Parents were instructed in the administration of simple oral analgesics and issued with a two-part questionnaire and a stamped addressed envelope before their child's discharge. The questionnaire was similar to one employed

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Table 1. Mean (SD) age and weight of patients.

	Group C (caudal $n=18$)	Group D (diclofenac $n=20$)
Age, years	5.3 (2.5)	4.7 (3.1)
Weight, kg	19.2 (4.8)	17.7 (7.7)

previously[2] and contained sections to be completed on the evening of surgery and on the morning of the next day. The parents were asked to record the child's degree of pain as none, slight or moderate on the first evening. They also noted episodes of vomiting, oral intake, the requirement for analgesia, the degree of mobility of the child, and if the child had passed urine. The parents were asked to make an assessment on the next morning of overnight pain (as before), the occurrence of vomiting, the quality of sleep and the requirement for analgesics.

Nominal data were analysed using the Chi-square test with Yates' correction. Parametric data were analysed with Student's unpaired *t*-test, $p < 0.05$ was taken as statistically significant.

Results

Forty-three children were admitted to the study. Questionnaires were incomplete or not returned in three cases, one patient was discharged early and therefore not assessed, and one patient was admitted to the ward overnight for surgical reasons and took no further part in the study. Demographic data for 38 patients therefore are shown in Table 1 and reveal that the groups were evenly matched for age and weight.

Eight patients who received diclofenac had moderate pain at the first postoperative assessment. The remainder had pain rated as none or insignificant. All patients who received a caudal had no or insignificant pain. This difference is significant ($p < 0.01$). There was no significant difference in respect of pain between the two groups at 2 and 4 hours postoperatively and no patient was observed to be in severe pain in the first 4 hours after operation (Table 2).

The questionnaire showed that the majority of patients in each group experienced no or slight pain on the evening of operation and that the groups were similar in this respect (Table 3). Additional analgesia in the form of paracetamol was required by comparable numbers in each group.

One patient who had a caudal and two who received diclofenac experienced nausea or vomiting 4 hours after operation. Two patients at this time (immediately before discharge) in group C were described as unsteady and complained of 'wobbly' legs. Side effects which occurred later are shown in Table 4.

Discussion

The results of this study indicate that, except in the immediate postoperative period, rectal administration of diclofenac provides analgesia comparable to that produced by caudal epidural blockade.

Table 2. Early postoperative pain—numbers of patients.

		1 hour	2 hours	4 hours
Group C	none/insignificant	18**	16	16
$n=18$	moderate	0	2	2
Group D	none/insignificant	12	18	19
$n=20$	moderate	8	2	1

**$p<0.01$ in comparison with Group D.

Table 3. Pain experienced after discharge—numbers of patients.

	Evening		Overnight	
Group	C	D	C	D
No pain	6	9	14	13
Slight pain	11	9	3	6
Moderate pain	1	2	1	1
Additional analgesia	10	11	5	5

NSAIDs may prove to be useful in the attempt to relieve postoperative pain in children; however, they may not be sufficiently potent to be effective for immediate pain.[8] Our results reflect this: superior analgesia was evident in the caudal group at 1 hour and only 60% of those who had diclofenac were pain-free at this time, although this proportion increased later. However, this may reflect a slower onset of action of diclofenac, since Tigerstedt *et al.*[9] did not observe any immediate benefit of intravenous diclofenac in the early postoperative phase in adults after general surgery. However, Maunuksela *et al.*[10] who used an infusion of indomethacin in comparison with placebo in the immediate postoperative period in children undergoing orthopaedic or general surgery, demonstrated a decreased need for morphine in recovery and for 24 hours. Diclofenac was shown to be effective in the management of postoperative pain after systemic administration in adults but its onset was again slightly delayed.[11]

Rapid absorption of diclofenac from the rectum was demonstrated[7,12] but it is possible that delayed onset of analgesia in children is due to some delay in absorption from the rectal mucosa. Reiss and colleagues demonstrated that diclofenac absorption after rectal administration was equivalent to that seen after oral administration.[7] No specific instruction was given to parents in respect of bowel preparation before admission, and thus the possibility of faecal presence in the rectum may have influenced absorption. A delay in absorption, and a further delay in onset of analgesic effect, would provide an explanation for the apparent superiority of caudal analgesia in the first hour after operation in our patients.

The incidence of side effects in this series was similar in the two groups and was remarkably low. Urinary retention was not a problem, although this has proved troublesome elsewhere:[13] no patient in this study failed to pass urine on the evening of operation. However, the incidence of unsteadiness of gait in the caudal group (11%) at 4 hours was of greater concern. This compares with an incidence of this side effect using a similar dose in a previous study, of approximately 14%[2] and is an alarming complication for a parent who is to accompany the child home. Side effects of diclofenac tend to be less severe than those of opioids.

Table 4. Side effects in the late postoperative period; numbers of patients.

	Group C	Group D
Vomiting:		
evening	4	4
overnight	0	2
No oral intake	2	2
Normal mobility absent	10	9
Not passed urine	0	2
Disturbed sleep	2	5

Those of nausea, vomiting and drowsiness were fewer in patients who received diclofenac for renal colic than for those who had pethidine.[14]

Previous studies have failed to demonstrate a clear superiority of caudal analgesia over other analgesic techniques. For example, ilio-inguinal nerve blockade,[13] wound infiltration,[2] and systemic opioid administration[3] are all as effective. Bramwell *et al.*[3] suggested that the degree of postoperative pain experienced after inguinal herniotomy was much less than that seen after circumcision or orchidopexy. It follows, therefore, that less invasive analgesic techniques than that of caudal blockade may be employed in preference.

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SPECIAL ARTICLE

Twenty-five years of ketamine

A report of an international meeting

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An international symposium held recently at the University of Michigan at Ann Arbor, the city of its origin, recognised the 25th anniversary of the introduction of ketamine in America. This was initiated and organised by Ed Domino, Professor of Pharmacology at the University of Michigan, who was responsible for the early pharmacological studies with the drug and who has maintained an unflagging interest in it over the years. It was synthesised in the 1960s, with first animal testing in 1962 and subsequent pharmacology studies in early 1964,[1–3] before the first human administration by Guenter Corssen to a volunteer prisoner in August 1966. Its pharmacology was reported in detail by Domino, Chodoff and Corssen in 1965.[4] The data presented to the licensing authorities were based on over 12 000 administrations, with a 13% incidence of problems during emergence.

The introduction of ketamine in Britain in late 1969 was described as a 'disaster' from which the drug never recovered. There were few planned clinical trials before marketing. The manufacturer's description of the drug as a rapid acting induction agent suitable for use as a sole anaesthetic for short procedures resulted in an unacceptably high incidence of emergence delirium. This had not been a problem with the 45-minute 'short' American operations but the drug was unsuitable for the 4–6 minute short British procedures.[5] Lack of expert anaesthetic input with this phase of its use resulted in many anaesthetists abandoning it after they had unexpectedly encountered problems in their early experience. It was a big mistake to regard it as a nonhypotensive substitute for thiopentone.[6] It took many years to evolve the concept that ketamine was a most valuable drug for use in selected situations rather than just another induction agent.

Many speakers testified to the ability of the injectable benzodiazepines to attenuate the emergence problems with ketamine,[7,8] but the need to steer a course between retention of the many advantages of the drug and the prolongation of action by diazepam or midazolam was also clear. The question remains unsolved as to whether diazepam has a specific action in the reduction of sequelae or whether this is due to the amnesic and soporific effects of diazepam. There was no consensus of opinion about the attenuation of the cardiostimulatory effects of ketamine.

Analgesia remains one of its outstanding advantages.[9] The drug has a weak affinity for opioid binding sites, and some studies suggest that it may act, in part, by the release of a humoral substance with opioid-like activity. The analgesia can be antagonised by naloxone, but only with much larger doses than are required to antagonise morphine.

What hope does one see for the future with ketamine? There were reports of promising results with ketamine–benzodiazepine combinations for sedation (in combination with local analgesic techniques) and for induction or even for continuous infusion, with a preference for midazolam over diazepam. However, the steeper dose-sedation slope with the former can readily result in oversedation. Despite their different pharmacokinetic profiles, promising results have been reported with ketamine–propofol combinations: this avoids the haemodynamic effects of the propofol and one waits with interest for detailed reports on this technique. Sufentanil–ketamine is another promising combination with a blunting of the cardiovascular stimulation caused by ketamine and good residual analgesia. There is a high incidence of rigidity with this combination but it also merits further study.

An increase in intracranial pressure is generally considered a bar to the use of ketamine in certain subjects.[10] Work presented at the symposium showed that this only occurred in patients who breathed spontaneously. This does not make it the drug of choice in patients with acute head injuries, because agents are available which lower intracranial pressure, but it removes the fear of using it in field conditions when it would otherwise be an ideal drug.

Ketamine is not dead. There appears to be some upsurge of interest in it in America, but even there its use has never achieved the same popularity as in continental Europe. Reports of large studies in these countries offer no explanation for these differences. Could it be a result of the method of its introduction?

Much research on its mode of action and biotransformation is being carried out in Japan. The biotransformation products of ketamine require further evaluation and the pharmacology of its enanthiomorphs offers hope that compounds can be prepared with a lower incidence of side effects, but these need to be studied in detail in large numbers of patients. An enthusiastic pharmaceutical input is needed for an extension of this work.

The symposium examined the status of ketamine in anaesthesia in 1989 and faced the question as to where a balance is achievable between its beneficial effects (pros) and side effects (cons). The answer to this is still not clear, but it is remarkable that interest is still maintained in this drug after 25 years despite the introduction of new intravenous and volatile agents as well as new opioids which are suitable for use during anaesthesia. Would the situation have been different if ketamine had been introduced after propofol, midazolam or alfentanil?

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ANAESTHESIA AND THE LAW

Caesarean section: pain and awareness without negligence

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In a landmark case decided in the High Court this summer,[1] Mr Justice Hutchison found that a patient had suffered periods of consciousness and pain towards the very end of an operation to perform a Caesarean section but that there was no negligence on the part of the anaesthetist whose notes and technique were impeccable. Liability having not been established, no damages would be payable; the judge said, however, that since he had considerable sympathy for the patient, he felt some regret at having been compelled to come to this conclusion.

The background facts

On 19 September 1983, the plaintiff, Mrs Davina Ludlow, then aged 28 had an elective Caesarean section in the Princess Margaret Hospital, Swindon. She gave birth to a healthy girl. (Her first baby was born on 30 November 1980, after a long labour, epidural anaesthetic, pethidine and ultimately a Caesarean section during which she was unconscious.) At the outset, all went normally. The anaesthetist Dr S.K. De, a Senior House Officer, started a conventional induction at 0925 hours which included 0.6 mg atropine. Once the patient was unconscious an 8-mm cuffed tracheal tube was inserted, and anaesthesia was maintained with a 50/50 mixture of N_2O and oxygen and 0.5% halothane until the birth at 0936 hours whereupon the mixture was changed to 66% N_2O and 33% oxygen and the halothane discontinued; but a large 20-mg dose of Omnopon was administered. The anaesthetist put earphones on the patient after induction; these transmitted white noise and he checked that they were working. Anaesthesia was reversed in due course, when the operation was completed shortly after 1000 hours.

The patient, however, subsequently claimed periods of awareness and great pain during the procedures which, in 1983, were accepted as unexceptional if they occurred as described. She described her experiences at the trial. The next thing she remembered after losing consciousness was a 'searing pain across her stomach', such a terrible pain that she thought she was not going to live, and indeed wanted to die. She said she was conscious of the tracheal tube in her throat and could 'feel her stomach being parted', was aware of the pain in two separate parts, still at an extreme level of intensity. She became aware of a machine making a constant noise at about this time: 'dee, dee, dee' more a bleep than a clunk. She thought she could hear a baby crying in the background and thought, 'Why have they brought a baby in when I'm dying?' By now the pain was less intense. She was not aware of a conversation, just a constant babble in the background. Subsequently, she clearly heard someone say, 'You can bring her round now'. At no stage could she move, open her eyes or speak. She had no recollection of the baby being born.

The patient said that shortly after hearing the instruction to bring her round and the increase in the rate of the machine (the 'dee, dee, dee' noise), she in fact became unconscious. When she regained consciousness, to find her husband and the baby with her, she was very upset and told him it had been terrible, that they had not put her out properly and that she had thought she was going to die. The next day she told her mother. She received the impression that neither her husband nor her mother regarded what she told them as important, since they were enthusiastic about the baby and this upset her further. The patient told one of the nursing staff what had happened and this resulted in a note in the nursing notes to the effect: 'Tearful and anxious today, apparently aware of what was the procedure during anaesthetic. Anxious that this might happen again. Reassured as much as possible, medical officer and anaesthetist to be informed.' There was a further note on the discharge form dated 26 September 1983. 'Patient says that during her Caesarean section under general anaesthetic she could hear what was happening (and was also feeling ?pain). During her next Caesarean section she wants epidural.' (In fact she had requested an epidural before her second baby but the hospital did not have the expertise available to provide one.)

The judge found that Dr De, the anaesthetist, was not informed of what the patient had said had happened (see later). He did not therefore see her, though some other anaesthetist did see her at some stage before she left. The judge said that it was a great pity that the nurse who made that entry in the notes and who obviously intended passing the information on to Dr De did not do so. Had she done so, he thought that Dr De would have come to see the patient 'and the explanations which he would have tendered and perhaps the reassurances he would have given might have been beneficial.'

Mrs Ludlow sued in negligence, and alleged that she was not properly anaesthetised. The defendants accepted that at some stage she was aware of what was happening. The vital question was when, why and was it as a consequence of any failure on the part of the anaesthetist to follow proper anaesthetic procedures and could the plaintiff prove that during a period of some 10 minutes, ending with the birth of the baby at 0936 hours, the anaesthetic mixture she was receiving did *not* contain halothane? If she established that, the judge said she was entitled to succeed, but if not, it was common ground that her claim must fail.

Anaesthesia for Caesarean gives rise to particular problems, because of the need to render the mother unconscious and to avoid injury to the baby with anaesthetic agents

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which are readily transmitted through the placenta. Research suggested in 1970 that the baby would be best protected if anaesthesia was maintained with a mixture of 50% oxygen and though this view is now doubted, if not discredited, in 1983 it still prevailed. (By comparison in an appendicectomy a patient might be given 66% or 70% N_2O to 33% or 30% oxygen). It was therefore also common practice to include in the anaesthetic mixture a small proportion of a volatile anaesthetic agent such as trichloroethylene or (latterly) halothane. However, a belief existed that even at low concentrations these substances could induce haemorrhage after birth, and accordingly in 1983 (at any rate) many anaesthetists would cease using them at the moment of birth. These and other obstetric anaesthetic practices were contained in a protocol, and adherence to it was obligatory at the hospital.

Dr De maintained a full, clear and meticulous anaesthetic record made as the operation progressed. He had not seen the note again until 24 July 1986, by which time he was working at another hospital and the plaintiff's solicitors had written a letter before action. The judge accepted the notes and Dr De's evidence as an accurate description of the anaesthetic procedures used and that they were not open to criticism. Expert evidence at the trial indicated that examination of 2500 cases of Caesarean section showed that even where N_2O at 50% and halothane at 0.5% was used, a small proportion (0.35% of cases) experienced awareness and that the published experience of Dr Selwyn Crawford was to the effect that 10% of those aware experienced pain. The difficulty here was that it was not admitted that the plaintiff was awake during the halothane phase; the fact that it was used on this occasion (and the judge rejected a suggestion that the halothane vaporizer was empty), pointed strongly to the plaintiff's period of consciousness probably having occurred at a later stage.

Patient's awareness occurring after discontinuance of halothane

The judge said that an analysis of the evidence satisfied him that the plaintiff's recollections were far from unequivocally attributable to the halothane phase. The only conversation she recalled was undoubtedly right at the end, half an hour or more after the halothane administered was discontinued. It was possible, that contrary to her belief, she had been unconscious for a spell and again awoken. The noise of the machine, and its increase in speed, the babble of voices, the abdominal pain (including the impression of parting) were all explicable as happenings in the final phase of the operation. Of particular significance were the things she did not remember: being touched by those attending to her; the birth; the distinctive hiss of white noise through the headphones (removed somewhat before the end of the operation). The crying of the baby could be referrable to a period just after birth (when she did cry) but it could have occurred and been heard considerably later. The absence of clinical signs such as sweating, lacrimation, and increased pulse strongly pointed to her not having been conscious during the early part of the operation.

Another material factor which should not be overlooked was that the plaintiff was under the influence of powerful drugs. This reflected not at all on her *credit*, which was wholly accepted, but on the *reliability* of her recollection.

Comment

During the last 10 years there has been an increasing anaesthetic input to obstetrics. Further, with a view to monitoring patient welfare in this area, one consultant at a leading teaching hospital has suggested that routine visits should be made by an anaesthetist to all patients in the maternity ward who have undergone anaesthesia. This consultant (and others present during a discussion of the case) also criticised the provision of strict protocols for anaesthesia the application of which was to be obligatory; doctors should be trained to use their discretion and not to act as automatons.

This case provides an example of poor patient handling; the opportunity for a meeting with the anaesthetist concerned was lost. The anaesthetist, unaware of any problem until 3 years later, had no chance of giving a contemporaneous explanation and apology for any distress.

Failure to acknowledge a patient's distress and to tackle it promptly and sympathetically can lead down the inexorable path of litigation and bitterness. In this case the plaintiff was legally aided with a zero contribution so, although the health authority and the defence society won their case, they will have to bear their own costs, while the public purse has funded those costs incurred by the plaintiffs. This situation is not untypical of many medical negligence claims and highlights the futility of litigation in so many cases.

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Femoral nerve block after intra-operative subcutaneous bupivacaine injection

Drs Lewis and Fell[1] described transient motor deficit in addition to the more common paraesthesia in the femoral nerve territory after ilio-inguinal and ilio-hypogastric nerve blocks for inguinal hernia repair. The neurological deficit was attributed to the local anaesthetic solution tracking across fascial planes; this includes the rather tough iliac fascia. We suggest that local perfusion through the loose areolar tissue is a simpler explanation and give an example below.

A 76-year-old man underwent routine left inguinal hernia repair for a large indirect sliding hernia. Shouldice technique was employed using '1' Novafil suture, and the internal ring was further narrowed with a lateral stitch. Twenty ml plain 0.5% bupivacaine (Marcain) was infiltrated before skin closure, into the subcutaneous tissue along the wound. The patient reported weakness of the left leg 6 hours after the operation. Examination revealed paresis of left quadriceps, reduced left knee jerk and anaesthesia over the anterior aspect of the thigh. The patient was observed with a view to exploration of the area should there be no improvement in the next 24 hours. Ultrasound scan showed no evidence of a wound haematoma. Overnight the weakness in the left leg recovered fully.

It has been argued[2] that surgical trauma to the femoral nerve is more likely than local anaesthesia to be the cause of postoperative neurological deficit. No undue traction was used in our patient and the possibility of traction neuropraxia was considered unlikely. Pressure from a haematoma was excluded on ultrasound scan. Direct injury to the nerve by a needle prick or suture ligation would be unlikely with the rapid recovery of the neurological deficit.

The external oblique in a routine inguinal herniorrhaphy

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is cleaned of the overlying membranous Scarpa's and fatty Camper's fasciae to just below the inguinal ligament before it is incised for exploration of the inguinal canal. The femoral nerve would thus be exposed except for the presence of a thin layer of areolar tissue. There is often pooling of local anaesthetic in the wound as noted in our case despite careful injection subcutaneously. We postulate that, instead of traversing the fascial plane[1,3] the local anaesthetic superficial to the external oblique layer simply diffuses through the areolar tissue to reach the femoral nerve. Similar local diffusion may occur after regional block if some of the anaesthetic agent is deposited subcutaneously and tracks down towards the inguinal ligament.

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Anaphylaxis and chymopapain

We were most interested to read of the life-threatening anaphylactoid reaction to chymopapain reported by Smith and Hofmann (*Anaesthesia* 1989; **44:** 767–9). This case afforded them the opportunity to present an excellent review, but we consider that their management of anaphylaxis and choice of anaesthesia cannot pass without comment. We question their logic in the advocacy of the use of crystalloid fluid to restore circulating blood volume largely lost through impaired capillary permeability. The deficit may be considerable[1] and rapid restoration with colloid is fundamental to successful resuscitation, along with correct medication including the early use of adrenaline. The authors' arguments against colloid included cost and availability (neither should present a problem in a hospital using chymopapain); antigenicity (not relevant in the face of an overwhelming immune reaction) and transmission of infection (what about the synthetic plasma expanders?) Their patient developed hypoxaemia, a grossly swollen arm and required controlled ventilation of her lungs for 3 days after 4 litres of normal saline. Perhaps colloid would have effected a speedier resolution with less chance of development of pulmonary or peripheral oedema.

We also avoid general anaesthesia for chemonucleolysis, though arguably it provides a more controlled environment should the rare reaction occur. There is usually a delay before chymopapain reaches the circulation to trigger a reaction if it is (correctly) instilled into the centre of an intervertebral disc. Early warning of 'impending doom' however may come from complaints of tingling or burning by the patient and these of course cannot be expressed under general anaesthesia. McCulloch and Macnab,[2] who first described these prodromal symptoms of chymopapain anaphylaxis, strongly advocated the use of a local analgesia/sedation technique, and noted that not one of 15 patients with reactions required tracheal intubation, because of the prompt recognition and treatment of anaphylaxis.

We have refined the technique of McCulloch and Macnab and give opiate premedication (papaveretum and hyoscine), followed by midazolam sedation titrated to an end-point of calm cooperation in our series of 350 cases. The intradiscal needle can be positioned after a generous 'wedge' of lignocaine is instilled, with the patient still responsive to it impinging on nerve roots (thus minimising the risk of neural damage). The patient is able to confirm the correct lumbar level at stress discography where this is in doubt. We give methohexitone to provide a necessary period of perfect stillness for the chymopapain injection, and recovery from this is fairly quick. We monitor our patients closely during and after the procedure and are prepared to treat a reaction immediately. We have had one patient with anaphylaxis. Marked cutaneous erythema, wheeze and tachycardia were aggressively treated with 1 litre of plasma protein solution and adrenaline given subcutaneously, and fortunately the patient suffered no collapse. A substantial percentage of our patients enjoy complete amnesia for all events in theatre after insertion of the intravenous cannula.

We are currently surveying some 300 centres in Europe (70 in the UK) about the anaesthetic management of chemonucleolysis. There is no doubt that the early, alarming 1% anaphylaxis rate in the United States of America is reduced particularly in Europe, where it is now estimated at 0.2% in a large multicentre surgical survey.[3] This improvement is attributed to the greater use of local anaesthesia and the early recognition of a reaction. We do not yet pretreat with H_1 and H_2 antagonists at doses which might be sufficient to modify or quell a reaction, because we do not wish to inflict unnecessary medication on the 99.8% of patients who do not need it. We are however moving to radio-allergogenic skin tests before the procedure partly as a result of the local medicolegal climate after Sherriff Kelbie's pronouncements, but chiefly in preparation for the evaluation of a skin test which will become available in 1990. Finally, it should be noted that chemonucleolysis, while it has enjoyed a certain notoriety in some circles, was shown to have one tenth the mortality and morbidity of laminectomy,[3] and has a 75–80% success rate in sparing patients with prolapsed discs the need for surgery.

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Propofol for Caesarean section

We read with interest the two articles by Moore *et al.* and Valtonen *et al.* (Anaesthesia 1989; **44:** 753–7 and 758–62) about propofol for induction of anaesthesia for Caesarean section. We would like to make some comments and comparisons with other studies.

Neither paper appears to have controlled the time from induction to intubation nor the rate of fluid administration over the induction period. Moore *et al.* conclude that blood pressure was lower in the propofol group during the induction–delivery interval, but it could be equally stated with different connotation that the thiopentone group showed higher blood pressures. The authors have noted that the cardiovascular response to tracheal intubation is less with propofol than with thiopentone so that propofol may actually promote more cardiovascular stability. Statistical analysis was performed with the unpaired *t*-test, but a comparison of individual blood pressures after induction with baseline blood pressures, with repeated measured analysis of variance, would be preferred. Similarly, the incidence of patients with systolic blood pressure less than 100 mmHg was said to be significantly greater in the propofol group. It is possible that these readings were taken successively from a few patients in the propofol group who normally had low blood pressure, and a comparison to pre-operative values is again required to clarify this. It also appears that the change in mean arterial blood pressure was *higher* in the propofol group (see their Fig. 1).

A study in 40 patients compared propofol 2 mg/kg with thiopentone 4 mg/kg; there was no change in blood pressure immediately after induction but the hypertensive response to laryngoscopy was significantly less in the propofol group.[1]

Both studies reported similar Apgar scores in both groups. This confirms some reports[1,2] but not others which found lower Apgar scores in the propofol group.[3,4] A higher dose of propofol (2.8 mg/kg) was administered in the latter study. No correlation has yet been demonstrated between Apgar scores and propofol levels but this may represent the insensitive nature of the assessment. Neurological and adaptive capacity scores were lower when umbilical venous levels were high, but testing was not performed until 15 minutes after blood sampling.[5]

The UV/MV ratios of propofol found by Moore *et al.* are similar to past reports of 0.65[6] and 0.68.[2] UA/UV ratios previously published (1.07[6] and 1.09[2]) are higher than those by Valtonen *et al.* Their induction-to-delivery times (4–7 minutes) were shorter and their results reflect continuing fetal uptake of propofol at this early stage. This is similar to the situation that occurs during continuous infusion of propofol.[7] The finding that clearance of propofol is greater in Caesarean section patients compared to nonpregnant women who have laparoscopy[8] is of additional interest.

Propofol does not appear to have significant clinical advantages over thiopentone and is unlikely to replace it as an induction agent for Caesarean section. However, infusion techniques may be more promising, because their use allows higher concentrations of oxygen to be given in cases of fetal hypoxia without risk of maternal awareness or the use of high concentrations of volatile agent.[1]

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A reply

The comments by Drs Gin and Gregory are interesting and we look forward to their publications on the use of propofol in obstetrics. It is important to read our paper in the context that propofol was an untried induction agent for general anaesthesia for Caesarean delivery and the main aim of our investigation was to establish that no serious hazards for mother or infant were associated with its use and to indicate guidelines for its further investigation. It is our view that hypotensive episodes during the induction–delivery interval commonly occur sporadically and are corrected by further uterine displacement or intravenous fluid therapy. The cardiovascular response to tracheal intubation in light anaesthesia is blood pressure elevation and tachycardia. Our study indicated that hypotensive episodes and this response to intubation were different after propofol compared with thiopentone. Indeed, the hypotensive episode with propofol indicates caution with its use.

There is no doubt that repeated measures analysis of variance would have given a better overall evaluation, but since the induction–delivery period was considered the most critical, the variable delivery time meant that a decreasing number of readings would be available and this reduces its validity. Our comment on the definition of significant hypotension in the parturient is prominently written with references in the discussion. The other comments are noted. The umbilical/maternal vein ratios for thiopentone and propofol are wrongly printed in the summary and should read 0.85 and 0.72 respectively.

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Atracurium and hypoxaemic episodes

A 13-year-old girl, who weighed 27 kg required anaesthesia for systemic pulmonary shunt operation. Cardiac catheterisation revealed that she had a ventricular septal defect, pulmonary atresia and absent proximal left pulmonary artery. She was cyanosed and the oxygen saturation ($Sa\text{O}_2$) was 70%.

She was premedicated with morphine 2 mg and hyoscine 0.1 mg intramuscularly about one hour before surgery. ECG, arterial pressure, central venous pressure and $Sa\text{O}_2$ with a pulse oximeter were continuously monitored. An uneventful induction was with fentanyl 50 μg, thiopentone 100 mg, and atracurium 15 mg. Her trachea was intubated and her lungs ventilated with a Servo 900C ventilator. Anaesthesia was maintained with 50% oxygen in nitrous oxide, isoflurane 0.5–1.0% and supplementary doses of fentanyl. Weak respiratory movements were observed about 15 minutes after the onset of surgery, and intravenous atracurium 5 mg was given. The $Sa\text{O}_2$, which was 72%, decreased rapidly 3 minutes after this; the lowest value recorded was 48%. Change of $F\text{IO}_2$ to 1.0 did not help. Ventilator settings and haemodynamic variables remained the same. There was no sign of bronchospasm. Metaraminol bitartarate 0.5 mg was given and the $Sa\text{O}_2$ started to increase; it was 70% within 2 minutes. The $Sa\text{O}_2$ again decreased to 54% when another dose of atracurium 5 mg was given later and was treated successfully with aramine 0.5 mg. Neither of these episodes were related to surgical events, such as clamping of pulmonary artery or manipulation of heart and great vessels. Pancuronium was substituted for atracurium without incident when further neuromuscular relaxation was needed. The procedure was uneventful afterwards.

An hypoxic episode in a patient with pulmonary atresia is most likely to be the result of an increase in the existing right-to-left shunt. This occurs as a result of decrease in systemic vascular resistance (SVR). A vasoconstrictor, by raising the SVR, can reverse or decrease the right to left shunt.[1] Sokoll *et al.* have reported that atracurium does not cause significant changes in haemodynamic variables during isoflurane anaesthesia,[2] but it has been shown that bolus doses could cause slight decreases in SVR which are statistically not significant.[3,4] Therefore, it may be presumed that atracurium, by decreasing the SVR, can aggravate the shunt and cause hypoxaemia with only a mild decrease in arterial pressure. Hypoxaemia was not noticed after the intubating dose of atracurium, probably because of the sympathetic stimulation caused by intubation and positioning.

The risk of hypoxaemic episodes after atracurium in predisposed individuals has not been assessed or reported but it is timely to warn anaesthetists of this problem.

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A dangerous failure of a pulse oximeter

A Kontron 7840 oximeter was in use during one-lung anaesthesia in a patient for a lobectomy. The pulse oximeter displayed an oxygen saturation of 95% and a pulse rate of 139 beats/minute; the bar display of the pulse waveform appeared to function normally. However, the rate was 92 beats/minute on the patient's ECG monitor. The oximeter was detached and the gas supply to the patient changed (from 50%) to 100% oxygen and 2% enflurane for the remainder of anaesthetic. The patient woke and recovered uneventfully at the end of the procedure.

The pulse oximeter was found later to display a saturation of 95% and a pulse rate of 139 beats/minute whenever the probe was put onto a subject's finger, although the bar display of the pulse waveform matched the subject's true pulse.

It is clear that if this pulse oximeter can fail whilst it displays a falsely normal oxygen saturation it could easily have disastrous consequences. There was a large discrepancy in this case between the ECG and oximeter pulse rates which allowed early fault detection but this may not always be so.

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A reply

Thank you for inviting a response to the above report.

It is indeed the case that the device concerned, when returned to us, exhibited the faults described. This was traced to a corruption of the instrument's RAM, which would appear to have occurred after heavy use of diathermy; a major cause of erroneous readings on many types of pulse oximeter. The Safety Information Bulletin, (88) 46 July 1988, does refer to this potential problem.

Kontron Instruments have circulated a Mandatory Modification Notice to all Medical Physics Departments, associated with hospitals, where type 7840-000 pulse oximeters have been delivered. The enhancement includes a change of software (to revision 8.06.1 from 7.11.1 or lower), and exchange of unscreened sensors for screened.

Should users believe that their 7840 Pulse Oximeters need modification they should contact their Medical Physics/Electronics Departments who will coordinate the upgrading programme locally. Any readers who have units that are not satisfactorily covered by this arrangement should contact us.

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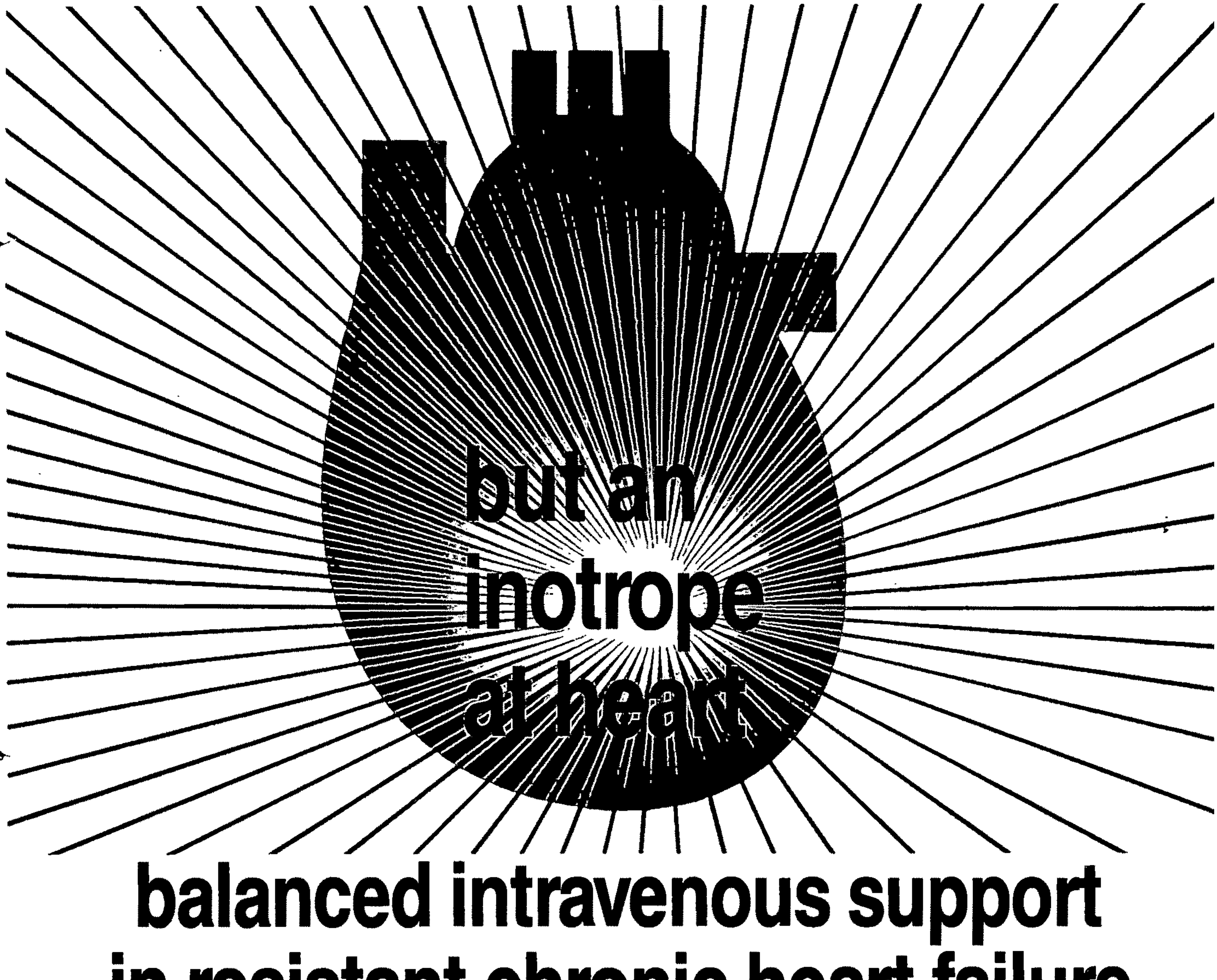

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The laryngeal mask: cautionary tales

A fit 48-year-old male smoker was anaesthetised for a transurethral resection of a bladder tumour, using a sleep dose of thiopentone and spontaneous ventilation through a size 4 laryngeal mask of nitrous oxide, oxygen and halothane, and a Lack system. Vascular access was secured with a size 16 Vygon indwelling catheter and compound sodium lactate infused. The operation, which was uncomplicated, lasted 40 minutes and blood pressure, ECG end-tidal carbon dioxide and oxygen were monitored throughout. They were all satisfactory. Everything proceeded smoothly and at the conclusion of surgery the halothane and nitrous oxide were discontinued; the patient was allowed to breathe 100% oxygen. It was intended that the laryngeal mask would be removed in recovery when full reflex activity had returned, as suggested in the manufacturer's instructions. However, before he left the operating theatre and whilst still unconscious, he coughed and immediately developed laryngeal stridor. The oxygen saturation started to decrease and the patient was noted to be dusky and to have a tachycardia. The laryngeal mask was immediately removed and the patient's trachea intubated with a 9.0-mm tracheal tube (after 100 mg suxamethonium). The oxygen saturation decreased briefly to about 80%. Tenacious mucoid secretions were noted to cover the larynx which were the obvious cause of the laryngeal stridor!

The patient was then extubated under deep halothane anaesthesia and the larynx carefully checked for secretions. His recovery was then supervised in the normal manner without any further problems. It can only be assumed that the presence of the laryngeal mask in a patient, a smoker with a heightened cough reflex, recovering from anaesthesia, held the secretions onto the larynx and potentiated what was the rapid development of laryngeal stridor.

This case is reported as a cautionary tale to remind my colleagues that if they delegate the removal of a laryngeal mask to anyone other than an anaesthetist, perhaps a recovery nurse, then an anaesthetist must be immediately at hand to deal with any airway problems.

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We are writing to confirm Dr Payne's concern (*Anaesthesia* 1989; **44:** 865) about regurgitation risk during the use of the laryngeal mask airway (LMA). We enquired about its use by 17 anaesthetists in Aberdeen hospitals, and have had eight reports of regurgitation amongst 546 'fasted' patients in whom the laryngeal mask was inserted. There was evidence of aspiration of gastric contents in two of these patients.

One patient was a 50-year-old woman who sustained multiple injuries. She had bilateral fractured ankles for which she was scheduled for internal fixation 24 hours after admission. She had not taken anything by mouth for 2 hours before her injury and 26 hours before surgery and had received papaveretum as an infusion for analgesia. A size 3 LMA was inserted without difficulty after pre-oxygenation and 80 mg propofol, and maintenance was continued with spontaneous ventilation of 100% oxygen and isoflurane 1.5%. One-and-a-half hours after induction, she developed signs of respiratory obstruction with audible wheeze and poor movement of the reservoir bag. The pharynx was suctioned and scanty vomitus was noted. Suction down the lumen of the LMA revealed the presence of more regurgitated fluid. The patient was then paralysed and the trachea intubated. Suction of the trachea and bronchi resulted in copious amounts of aspirated stomach contents. Bronchoscopy revealed green mucous aspirate which coated both main bronchi, especially the right main and middle lobe bronchi. No solid lumps were found.

The second patient was a 29-year-old woman who weighed 58 kg. She was for elective, day-case, laparoscopic sterilisation. There was no history of gastro-oesophageal reflux, or indigestion and there was no other significant past medical history. The patient had fasted for 12 hours before surgery and did not receive any sedative premedication before induction. She received metoclopramide 10 mg intravenously on arrival in the anaesthetic room. She was pre-oxygenated for 3 minutes before induction with propofol 175 mg (mixed with lignocaine 15 mg) papaveretum 15 mg, and vecuronium 3 mg. A size 4 LMA was inserted without difficulty at the first attempt. Ventilation of the lungs was controlled with a minute volume of 9 litres of 33% oxygen, 66% nitrous oxide and 1% enflurane. The patient was put in the Lloyd-Davies position with a 15° head-down tilt. Airway pressure at 15 minutes after induction was 1.5 kPa with a tidal volume of 630 ml. Leak pressure (as described by Brodrick *et al.*[1]) was 3.2 kPa. Regurgitation was recognised by the sudden appearance of fluid within the translucent tube lumen of the LMA just before the end of the procedure. Fibreoptic bronchoscopy through the LMA tube lumen revealed some staining around, and 3–5 cm below, the vocal cords. There was no evidence of aspiration in the lower half of the trachea or main bronchi.

The LMA is likely to remain contraindicated in the unfasted patient because regurgitation and possible aspiration remain a risk whether ventilation is spontaneous or controlled. The risk of silent regurgitation is also present even when there are no obvious predisposing factors.[2,3] We emphasise the need for constant vigilance when this airway is used, especially since the ease with which it is inserted and the excellent airway obtained in the vast majority of patients may tend to give those inexperienced in its use a false sense of security.

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Dr Brain recommends[1] and Dr Payne reiterates[2] that the laryngeal mask airway (LMA) does not protect against aspiration of gastric contents. A recent personal case demonstrated this beyond doubt. The LMA is no substitute for a correctly placed cuffed tracheal tube when a patient is at risk of regurgitation.

A 36-year-old woman presented for elective ablation of the atrioventricular node. She had no significant medical problems other than her paroxysmal atrial tachycardia. This was treated with diltiazem until the week before anaesthesia but no other medication was used. She had received an anaesthetic for evacuation of retained products of conception 4 years before and had suffered from nausea after this. She was starved for 6 hours before operation.

Premedication was with temazepam 20 mg, orally 1 hour before induction of anaesthesia. ECG monitoring was started and anaesthesia induced with etomidate 16 mg intravenously. Anaesthesia was continued with nitrous oxide, oxygen, and isoflurane. A size 3 LMA was inserted without difficulty. The cuff was inflated with 30 ml of air and this maintained a good airway. Her blood pressure and oxygen saturation were well maintained throughout the successful procedure and after one hour and 10 minutes the breathing mixture was changed to oxygen 100%.

Recovery was allowed to start with the LMA left in place. This maintained a good airway with the patient still supine. The patient then vomited with copious yellow vomitus coming up in the lumen of the LMA and passing into the breathing system. She was promptly rolled into the right lateral position and the LMA removed immediately. Her pharynx was allowed to drain through the mouth and further toilet carried out with a Yankauer sucker. Her subsequent recovery was uneventful after a second period of vomiting. Radiological examination of her chest after 6 hours showed no abnormal pulmonary shadowing.

The laryngeal mask should be considered to be an alternative mask and never an alternative 'tube'.

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References

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Recent correspondence has reinforced the notion that the laryngeal mask does not protect the patient from aspiration. The letter from Payne (*Anaesthesia* 1989; **44:** 865) stated that on bronchoscopic inspection, the oesophagus was visible through the mask in three of 50 patients.

We report a patient who vomited on emergence from anaesthesia in whom the vomitus was seen entering the tube of her laryngeal mask. Indeed, upon its removal, vomitus was seen to be confined to the internal surfaces, whilst the pharyngeal surface and the pharynx itself were both clean. This suggested that the vomitus was directed into the larynx and was unable to pass the cuff into the pharynx or mouth.

The potential combination of larynx and oesophagus included in the mask and occlusion of the pharynx above would be dangerous in a patient at risk of regurgitation. The recent suggestion of its use after a failed tracheal intubation in obstetric practice by Reynolds (*Anaesthesia* 1989; **44:** 870) should be viewed with caution if it is intended to protect the airway rather than maintain it in the presence of continued cricoid pressure.

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The laryngeal mask and difficult tracheal intubation

A 6-year-old boy with a known diagnosis of arthrogryphosis multiplex congenita was recently anaesthetised by us for correction of ptosis.

This child was anaesthetised previously on several occasions in this hospital for various ocular and orthopaedic procedures, and all his anaesthetics had been uneventful. He had undergone surgery for ptosis correction 6 months earlier, and the anaesthetic record showed that his trachea was intubated without any problem. One of us (A.R.) anaesthetised him 2 months before this event for an orthopaedic procedure at which time a size 2 Laryngeal Mask Airway (LMA) was used without laryngoscopy.

He presented to the anaesthetic room awake and calm, after a standard premedication of trimeprazine, atropine and EMLA cream. We decided, since he was awake, to proceed with an intravenous induction using thiopentone and suxamethonium. His lungs were inflated without difficulty with 100% oxygen via a mask and breathing system once he was asleep and paralysed. However, at laryngoscopy it was impossible to visualise the cords due to the presence of a large mass of lymphoid-like tissue (approximately 2 cm × 3 cm) which arose from the base of the tongue and obscured the posterior surface of the epiglottis, only the tip of which could be seen. Anaesthesia was continued using isoflurane and nitrous oxide in oxygen, once spontaneous ventilation was re-established, and a size 2 LMA was inserted with no problem. Surgery was completed with the airway thus secured with spontaneous ventilation throughout.

Direct laryngoscopy was performed by an ENT surgeon before anaesthesia was discontinued, and it was decided to re-admit the child at a later date for further investigations and probably an excision biopsy of this mass.

This case once again demonstrates the value of the Brain LMA in anaesthetic practice.[1–3]

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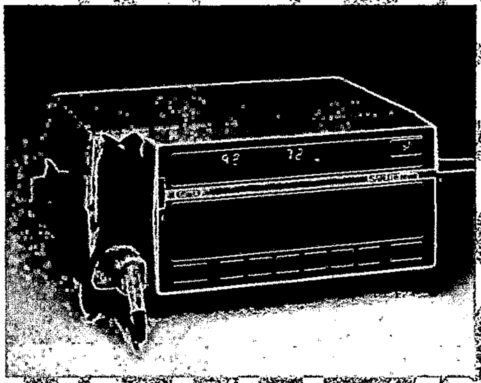

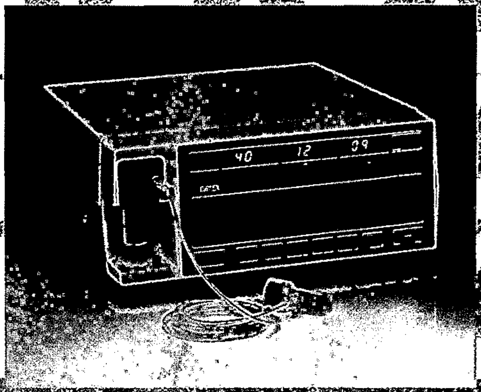

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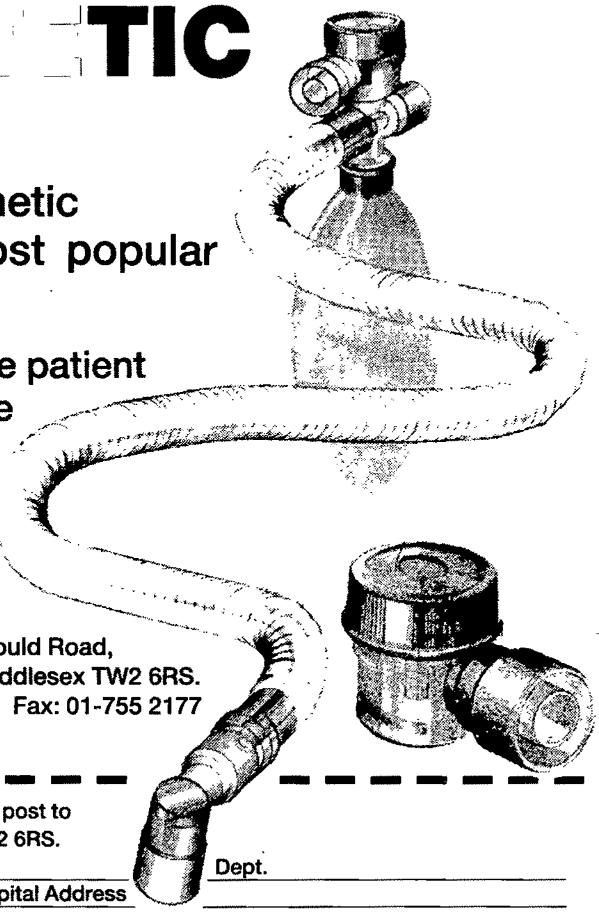

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The management of hyponatraemia

Drs Robinson and Ravalia (*Anaesthesia* 1989; **44:** 861–2) are correct to state that the management of acute water intoxication induced by hypotonic glycine is occasionally a medical emergency. However, their advocacy of the use of ×5 molar saline (29.2%) is, I submit, inappropriate for general use.

Their regimen, based on that successfully used by Worthley *et al.*[1] involves the administration of 250 mmol of 29.2% saline over 10 minutes. Clinicians less familiar with such solutions would be better served with ampoules of molar (5.85%) saline; they have for years used molar sodium bicarbonate and know that each ml of such a solution contains one millimole of the salt. The additional water load of 200 ml would be inconsequential.

Present concepts of the risk of pontine myelinolysis suggest that overcorrection of hyponatraemia is a likely cause and occasional users of exceedingly hypertonic saline would be more likely to subject their patients to this risk.

The use of so-called 'fifth normal' (0.18%) saline and to a lesser degree compound sodium lactate are less appropriate crystalloids during surgery than isotonic saline in this context.

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Reference

1. Worthley LIG, Thomas PD. Treatment of hyponatraemia seizures with intravenous 29.2% saline. *British Medical Journal* 1986; **292:** 168–70.

Diabetes and hypotension

Many diabetic patients require surgery for peripheral vascular disease. Peri-operatively, three factors commonly exist which may, singly or in combination, cause sudden hypotension. These are background autonomic neuropathy, absolute or relative hypovolaemia and intrathecal anaesthesia. (Currently the clinical significance of a potential fourth factor, the impaired cardiovascular response to hypovolaemia due to hyperinsulinaemia in patients with autonomic neuropathy, is uncertain.)[1] A recent experience of ours suggests that vagally mediated reflex bradycardia due to bladder distension might be added to this list.

We anaesthetised a 72-year-old man, who had suffered from insulin-dependent diabetes mellitus for 22 years, for a crossover femoropopliteal graft insertion. His diabetic control before operation was good on a combination of medium and short-acting insulins and he denied both postural hypotension and bladder symptoms. A dextrose/insulin/potassium infusion was started and the procedure performed uneventfully with minimal blood loss under spinal anaesthesia. One hundred and fifty ml of blood drained quickly from the wound site 2 hours later. The patient suddenly became unconscious and a sinus bradycardia (30/minute) with no detectable blood pressure was noted. A sample of blood was taken (later revealed to have blood glucose 11 mmol/litre), and dextrose 50% (30 ml), atropine (1.2 mg) and ephedrine (10 mg) were given intravenously. The pulse rate and arterial blood pressure rose (90/minute and 90/60 mmHg respectively) but the diminished levels of consciousness and peripheral perfusion persisted. The patient's general condition improved promptly and completely when a urinary catheter was inserted and 700 ml urine were drained.

The remainder of his course was uneventful. The presence of an autonomic neuropathy was later confirmed using heart rate responses to the Valsalva manoeuvre and to change in posture.

It is likely that the reaction described was due to a combination of factors but the dramatic improvement only occurred when the bladder distension was relieved. Spinal anaesthesia and diabetic autonomic neuropathy predispose to urinary retention. We conclude that, in such cases, in addition to testing cardiovascular reflex function before operation and to the meticulous measurement and replacement of blood loss, the insertion of a urinary catheter is prudent. The risk of infection is outweighed by the risk of such a reaction as we describe.

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Reference

1. Scott AR, Bennett T, Macdonald IA. Effects of hyperinsulinaemia on the cardiovascular responses to graded hypovolaemia in normal and diabetic subjects. *Clinical Science* 1988; **75:** 85–92.

Another cause for bradycardia during neurosurgery

It is a well known that neurosurgical procedures are often associated with severe and occasionally life threatening bradycardias. Such manoeuvres include traction on the meninges, spinal cord compression and manipulation of the fifth cranial nerve. However, we report a new cause of neurogenic bradycardia during craniotomy, namely, the application of vacuum suction via extradural drains.

It has become common practice in our neurosurgical unit to insert an extradural drain during the surgical closure after routine craniotomies. Once the drain is in place and during the final skin closure, vacuum suction up to 200 mmHg is applied directly from the wall vacuum system to prevent clotting within the drain, an objective which cannot be achieved with the ordinary pressures generated from the routine use of portavacs.

We have witnessed severe bradycardia on five different occasions, two of which have resulted in transient episodes of asystole, which resolved spontaneously on termination of this high vacuum suction. The mechanism of this reflex is thought to be due to a combination of marked negative intracranial pressure and the resulting traction on the meninges.

We consider that anaesthetists should be aware of the possibility of extreme bradyarrhythmias during wound closure and to continue vigilant monitoring of the patient at this stage. It may also be prudent to discourage this habit of the application of wall vacuum suction by neurosurgeons and that an alternative method be sought to keep the drain patent during skin closure.

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Epidural analgesia and hypotension

The aphorism 'when in doubt, take it out' (*Anaesthesia* 1989; **44:** 869) can certainly apply in many circumstances and safeguard the wellbeing of patients. However, in this case, certain facts should be established in order to clarify and understand the situation further before the above decision is reached.

An exaggerated hypotension resulted from an initial total dose of 7 ml 0.5% plain bupivacaine despite 1 litre crystalloid (which was a significant amount of fluid). The hypotension required 2 litres of colloid and 19 mg ephedrine as treatment. We regard this as a very unusual reaction to a normal epidural dose of 0.5% plain bupivacaine, with 'no other evidence of subarachnoid or intravenous injection of local anaesthetics'. What was the posture of the patient? The answer excludes aortocaval compression as a cause. What was the level of sensory block? This reveals the extent of sympathetic block and what was the degree of motor block?

Hypotension occurred with each of the four additional relatively small doses. Residual peripheral vasodilatation normally helps to reduce the degree of hypotension caused by subsequent doses depending on the interval between doses. It is well recognised that unopposed parasympathetic overactivity may lead to sudden extreme hypotension and this can occur even with low spinal blocks. Bradycardia may also be as a result of activation of the Bainbridge reflex; right atrial pressure receptors respond to decreased venous return. The report did not mention the heart rate. Ephedrine or atropine would have been more appropriate (instead of fluids) for use in bradycardia-induced hypotension. Moreover, simple corrective manoeuvres such as adjustments to posture, may be all that is required to restore blood pressure and avoid the unnecessary hazards of a repeat epidural.

Fluids mismanagement occurs frequently in epidural blockade during labour. Up to 500 ml crystalloid is often given freely for each increment despite a satisfactory blood pressure. We believe that there should be a protocol on labour ward about epidural analgesia and hypotension for the midwifery and anaesthetic staff if iatrogenic fluid overload and pulmonary oedema are to be avoided. Our protocol gives instructions about the correct posture for the mothers and prophylactic 500 ml compound sodium lactate for epidural analgesia in labour. The mother should lie on her side if hypotension occurs and the rate of the intravenous infusion be increased. However, if the blood pressure does not respond to the infusion of up to 500 ml of crystalloid (or gelatin) given rapidly the anaesthetist should be consulted.

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Problems with open-end catheters and epidural infusion

It was interesting to read the article (*Anaesthesia* 1989; **44:** 578–80) on the comparison between open-end and closed-end epidural catheters since we have also encountered problems with open-end catheters. The standard epidural catheter in this hospital is the Portex closed end (3 lateral holes). Analgesia is initially established with a total of 10 ml 0.5% bupivacaine followed by a continuous infusion of 0.08% bupivacaine provided by an infusion pump to maintain analgesia. Recently, due to delivery problems, we were supplied with open-end catheters.

Nine open-end catheters were sited in eight patients for pain relief during labour. The line occlusion alarm sounded persistently at both low and high infusion pressures on three occasions after the infusion pump was connected. There was no fault visible in the catheter or infusion set. Two cases were continued with manual top-ups but an increased injection pressure was required. The problem occurred in one patient after 4 hours of satisfactory analgesia and was reported by the nursing staff to have arisen immediately after the patient's position was changed. Resiting the epidural solved the problem in another patient who was still in early labour.

Measurement of injection pressure in an unpublished *in vitro* study showed no difference in the pressures required to inject through open-end and closed-end catheters. *In vivo* measurements in one patient with an open-end catheter showed no evidence of occlusion. Intermittent occlusion of the single hole by tissue in the epidural space may have caused the problem in the three patients. No such problems have been noted in this hospital in the last 3 years using Portex closed-end catheters (approximately 1400 per annum). This problem could be overlooked if injections are used since compensation with an increased manual injection pressure is possible.

We have noted an increased incidence of missed sensory segments when using open-end catheters which may be caused by the same mechanism, or by placement of the catheter tip close to a nerve root. We support the conclusions of Dr Michael *et al.* that there is a theoretical advantage in the early detection of intravenous and subarachnoid placements when open-end catheters are used. However, there may be an increased incidence of intermittent occlusion and missed sensory segments than when closed-end catheters are used.

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Comparison of anxiety before induction of anaesthesia in the anaesthetic room or operating theatre

Drs Soni and Thomas wrote an excellent review of the history of anaesthetic induction rooms and studied the influence of anaesthetic induction rooms on patient anxiety (*Anaesthesia* 1989; **44:** 651–5 and 670–1).

It is routine in overseas centres to anaesthetise patients 'on the table' and I was surprised at how well patients tolerated what one had been led to expect would be an unnecessarily traumatic experience. The most impressive examples for me were those patients about to undergo coronary artery bypass surgery. The teaching in centres in the United Kingdom is that these patients would develop acute myocardial ischaemia if more were done to them than induction in a darkened room with a small 'Butterfly' needle in the back of the hand. These patients (admittedly well premedicated) in the University of Western Ontario were taken into the operating room, where the scrub nurse would courteously introduce herself to the patient, and then have full invasive monitoring (arterial and pulmonary artery catheters) set up under local anaesthetic. These included a baseline 12-lead ECG, recordings of haemodynamic variables, the electroencephalogram and even cerebral blood flow studies before anaesthesia was induced.[1] Had any of this activity caused enough anxiety to precipitate acute ischaemia it would have been evident on the ECG or haemodynamic studies, but in my personal experience of about 50 cases I saw none.

Drs Soni and Thomas have lucidly discussed the arguments for and against anaesthetic rooms, but it was disappointing that in their study they applied the adhesive electrocardiograph electrodes, but did not connect them to a monitor! Why not?

Gaining general acceptance for 'on the table' induction of anaesthesia as a routine will be difficult; old habits die hard, but I expect that the change will inevitably happen.

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T.E. WOODCOCK

Reference

1. WOODCOCK TE, MURKIN JM, FARRAR JK, TWEED WA, GUIRAUDON GM, MCKENZIE FN. Pharmacologic EEG suppression during cardiopulmonary bypass: cerebral hemodynamic and metabolic effects of thiopental or isoflurane during hypothermia and normothermia. *Anesthesiology* 1987; **67**: 218–24.

A reply

Thank you for the opportunity to reply. We are grateful to Dr Woodcock for his comments on our study. His observations while working in the USA really agree with our findings. We find it interesting and encouraging to note that even the high risk patients most likely to manifest their anxiety at induction did not, in fact, show any adverse haemodynamic effect because of the site of induction.

We applied the adhesive ECG electrodes to patients but did not connect them to the monitors to ensure that the pre-anaesthetic sequence was the same in both groups of patients. It was impractical to move the monitoring equipment from operating theatre to the anaesthetic room for those patients for induction in the anaesthetic room.

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D.A. THOMAS

Frequency of repeated neuromuscular stimulation

There is a limitation in the performance of a widely used peripheral nerve stimulator. The Bard Biomedical Digital Peripheral Nerve Stimulator has, as one option, the mode of 'T-4 Rep'. A 2 Hz train-of-four stimulus is repeatedly delivered at 12-second intervals when this is selected.

When the neuromuscular junction is blocked to about 95%, and only one twitch is elicited from the train-of-four, repeated stimulation at 12-second intervals causes a degree of fade. Thus when the peripheral nerve stimulator is set to 'T-4 Rep', the twitch height is consistently lower than it would be after a single train-of-four stimulation. This phenomenon does not occur if the train-of-four stimuli are repeated manually every 20 seconds (Fig. 1). The conclusion is that an interval of 12 seconds is too short to prevent interference, that is fade, from the previous stimulus.

Thus the Bard Biomedical Peripheral Nerve Stimulator demonstrates a lesser degree of neuromuscular transmission when set to 'T-4 Rep' than might be demonstrated with a lower frequency of stimulation.

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P.J.M. BAYLY

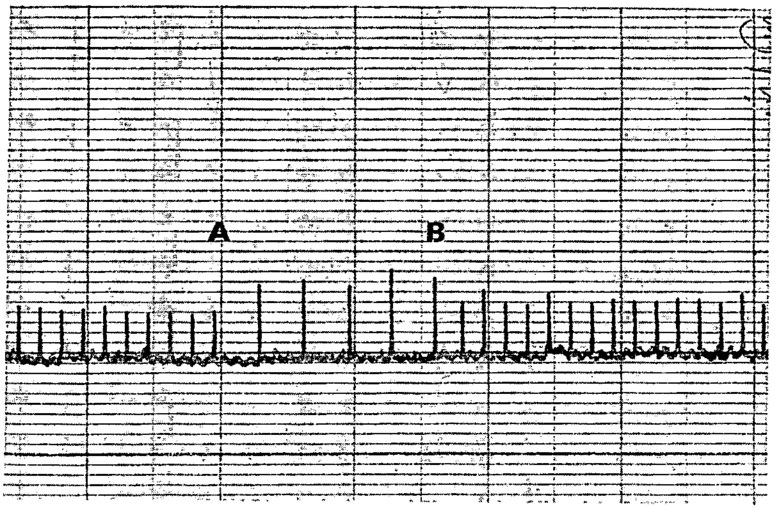

Fig. 1. The twitch response elicited from repeated train-of-four nerve stimulation, recorded via a mechanical strain gauge. Only the first impulse of each T4 produces a twitch. The interval between each T4 is 12 seconds, except between A and B, where the interval is 20 seconds.

Pneumothorax caused by minitracheostomy

This case report (*Anaesthesia* 1989; **44:** 663–4) was interesting. However, the authors imply the minitracheostomy tube was misplaced at insertion and thus caused the pneumothorax. Another possible cause of the pneumothorax could be displacement of the minitracheostomy tube after intubation, when the patient was positioned, or at extubation.

It has been shown that nasotracheal tubes in adults move an average of 1.5 cm (maximum 2.9 cm) towards the carina on neck extension, and 1.5 cm (maximum 3.5 cm) away from the carina on neck flexion.[1] Presumably, orotracheal tubes may also move significant distances. The cuff of the tracheal tube may have displaced the minitracheostomy tube from the trachea and allowed its tip to track down to the left pleural cavity either during positioning of the patient, or at extubation.

It is obviously a dilemma whether to leave a minitracheostomy in place when orotracheal intubation is required. There would indeed be a considerable risk of morbidity if the minitracheostomy were removed in the absence of a track.

If a minitracheostomy tube is left in place after intubation a careful examination and chest X ray would be wise after extubation to confirm the position of the minitracheostomy tube.

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Reference

1. Conrardy PA, Goodman LR, Lainge F, Singer MM. Alteration of endotracheal tube position. Flexion and extension of the neck. *Critical Care Medicine* 1976; **4:** 7–12.

Bain and circle systems

It was with interest and considerable disquiet that we read of the advocacy by Dr Kumar (*Anaesthesia* 1989; **44:** 791–2) of the use of a coaxial (Bain-type) breathing system within the circle for patients who are to breathe spontaneously. This is a departure from the conventional use of such a system and may, despite its convenience for the anaesthetist, be a potential hazard for the patient.

In bench measurements which we have made on the two coaxial systems commonly in use, the pressure drop across the inner coaxial element of the Bain-type system was 5.6 kPa at a flow of 30 litres/minute O_2. This is greatly in excess of the maximum value of 0.3 kPa recommended by Nunn[1] and increases the work of breathing to approximately 1 watt, assuming normal values for tidal volume, respiratory rate and I:E ratio. This represents, in our opinion, an unacceptable increase in the work of breathing and may compromise the safety of the patient.

Measurements on the Lack system (Medical and Industrial Equipment Ltd) showed that it is more appropriate for use in a circle system, as advocated by Sweeney and Tordoff;[2] its pneumatic resistance is on the limits of the Nunn recommendation, with a pressure drop of 0.3 kPa across both inspiratory and expiratory elements at flow rates of 30 litres/minute O_2.

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References

1. Nunn JF. *Applied respiratory physiology,* 2nd edn. London: Butterworths, 1977: 103.
2. Sweeney BP, Tordoff SG. A modified coaxial system for use with a circle absorption system. *Anaesthesia* 1989; **44:** 262–3.

The wise designer, since the time of John Snow, of anaesthetic systems has provided breathing channels of sufficient size to allow unrestricted respiration. However, in his letter (*Anaesthesia* 1989; **44:** 791–2), Dr Kumar suggests the use of a Bain system with a circle absorption system. The central channel of a Bain is not designed to carry respiratory gases; it normally takes the fresh gas from the machine to the patient; it is of small diameter (around 5–7 mm). This is totally inadequate for use as an inspiratory limb.

The fact that his patients came to no obvious harm confirms the robust nature of human physiology rather than the suitability of this circuit for this purpose.

The use of a Lack system with suitable modification, as described by Drs Sweeney and Tordoff (*Anaesthesia* 1989; **44:** 262–3) does provide breathing channels of suitable size for both inspiration and expiration. However, I do not think modification of the system in this way can be advocated since it is only a matter of time before someone uses an unmodified Lack system instead. Connecting the bag mount to the expiratory part of the absorber and shutting the exhaust valve would seem to be a logical approach and looks right to the inexperienced eye. However, if this is done the system no longer acts as a circle and the patient continually rebreathes the same gas from the inspiratory limb.

It is important, in times of increasing awareness of anaesthetic hazards, that equipment is properly designed for the purpose intended. If people require lightweight systems they can use lightweight disposable tubing (with nonflammable agents); if a coaxial system is really in demand then some manufacturer could be persuaded to make one, properly and unambiguously engineered. The use of coaxial systems, however, allows hidden faults to occur, principally disconnexion or kinking of the central pipe: both are potentially disastrous in a circle.

Inexperienced trainees have enough hazards to cope with without introducing these esoteric failures. It is surely safer to have pipes and connexions clearly visible, so that even the scrub nurse could tell you when something has come undone!

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Pain in the neck

A 31-year-old primigravida presented in labour at term and requested an epidural for pain relief. The epidural space was easily identified at L_{3-4} using the loss-of-resistance to air technique with the patient in the sitting position.

However, the catheter would not pass beyond the tip of the Tuohy needle. A second attempt was made at the L_{2-3} space with similar difficulties. Good progress in labour was anticipated so a single shot epidural was performed with plain bupivacaine. This provided good analgesia but the patient complained of 'shooting pains' in the neck above the level of C_7. Examination revealed a full range of neck movement with no meningism, there was no crepitus and subsequent lateral cervical X ray was normal.

Progress in labour was slower than expected and the epidural began to wear off 3.5 hours later. The patient used Entonox for pain relief for approximately one hour but complained of worse neck pain; she requested another attempt at an epidural which was successfully inserted at L_{2-3} and a good block established. A normal vaginal delivery ensued 2 hours later and the epidural catheter was removed. The neck pain persisted but slowly resolved over the next few days and the patient was discharged home well.

Neck pain and subcutaneous emphysema after lumbar epidural anaesthesia have been described[1,2] but this case illustrated an interesting added complication. Repeated attempts at siting the epidural in this patient resulted in the injection of larger than normal volumes of air. The epidural was sited with the patient in the sitting position and she remained mostly upright throughout her labour because she found this to be the most comfortable. The neck pain described by the patient was probably the result of gaseous distension of the cervical meninges; the air migrated cranially up to the attachment of the meninges to the foramen magnum.[2]

An interesting feature of this case was the worsening of the neck pain after nitrous oxide had been breathed. The effect of nitrous oxide within closed cavities is described and it is postulated that in this case, air trapped within the epidural space expanded in volume when nitrous oxide was breathed. Unfortunately, no attempts were made to reverse this effect by asking the patient to breathe 100% oxygen. A number of patients with epidurals *in situ* for pain relief in labour require a Caesarean section under general anaesthesia when the use of higher percentages of nitrous oxide could be potentially more damaging, if large volumes of air are present in the epidural space. A case for using saline to identify the epidural space?

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Kinked breathing systems

It cannot be emphasised too often (*Anaesthesia* 1989; **44:** 792) that a primary duty of the clinician, when any T-piece system is attached to the airway of a patient, is to ensure that the outflow pathway remains unobstructed at all times. The result of momentary obstruction connects the airway directly to the fresh gas flow and causes lung rupture such as Prince and Nicholls describe and, if not promptly rectified, extensive surgical emphysema and even death will ensue.

It is always the case that the clinician must ensure not only that the equipment which he uses is safe but also that the way in which it is used is safe. The dangers which are described are well known and that the way in which the expiratory pathway was handled, with the open-ended bag raised above the patient's head, is a technique which can be expected to produce the occlusion which occurred.

The solution suggested for avoidance of the danger by means of a pressure relief valve is readily supported. Indeed, it is my contention that the T-piece system should never be used unless this safety valve is included in the fresh gas flow line and I have in the past recommended that this should be the case.[1] Magnetic 'pop-off' valves were eventually designed for this purpose and these ensured that all T-pieces were provided with a relief valve which was incorporated in the system. A patient safety-pressure valve is necessary on all breathing systems and anaesthetic machines.

The Infant Breathing System which was used has silicon rubber tubing, which can I agree, easily kink if excessive curvature is imposed on it. This tubing was chosen specifically so that pressure effects on the scalp could be avoided at the points of attachment and so that torque could be applied to ensure that the nasal tube left the nostril in a downward direction. The use of 'armoured or corrugated tubing' would not be as satisfactory. It is my opinion that the Portex product is essentially a safe T-piece system especially if this danger is kept in mind and a pressure relief valve incorporated.

It is my hope that this latest report will make the incorporation of a pressure relief valve in the fresh gas flow line of all T-piece systems standard practice.

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Cost awareness among junior anaesthetists

We recently carried out a study to determine the extent to which junior anaesthetists in Sri Lanka were aware of the prices of drugs they used frequently. A questionnaire was given to 39 junior anaesthetists in which they were asked to estimate the cost to the Department of Health of 25 drugs and infusion fluids. The percentage variation of the estimated price of each drug was calculated based on a scoring system we devised.

The overall cost awareness was poor. Only 10.2% were able to estimate the prices of the 25 drugs to within 100%, and 20.4% estimated to within 200%. The estimates of 58.9% differed by more than 500% from the actual cost. Our findings are in agreement with a similar study among 10 junior anaesthetists in the United Kingdom.[1] The majority underestimated the prices of naloxone, atracurium and bupivacaine, all of which were relatively recently introduced into Sri Lanka. This probably reflects a lack of understanding of how costly new drugs can be. The only other drug of which the price was underestimated was tubocurarine. This remains a costly drug and is more expensive than pancuronium and alcuronium.

The prices of narcotic analgesic drugs were grossly overestimated. The controls governing their use and perhaps the narcotic connotation may have created an impression that they were expensive. The overall awareness of the drugs' cost was far from satisfactory but the majority thought that most of them cost more than they actually did. It would not be a bad thing if this influenced their practice. However, in the present economic climate it is important to improve cost awareness. Perhaps anaesthetic price lists should be displayed in every anaesthetic room, but updated at regular intervals to accommodate escalating prices.

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The costs of propofol in day surgery

Dr McWilliam (personal communication, 1989) generously concedes that his letter on the comparative drug costs of day-case general anaesthesia could be misleading (*Anaesthesia* 1989; **44:** 866). This is so partly because of his faulty arithmetic (see **45:** 76) and partly because he was unable to cost volatile agents and carrier gases. He also excluded value added tax (VAT); although VAT, while it increases absolute costs by 15%, does not affect comparative costs.

Dr McWilliam based his estimates on 82 day cases. Table 1 shows the average costs in our hospital of 1600 day cases for the financial year 1988/89. Extrapolating from his data, the mean increase in cost of a day surgery general anaesthetic using propofol as induction agent is not 2.5 times the drugs it has 'largely superseded' (Dr McWilliam means thiopentone): it is more like 1.6 times the cost. (Propofol, in effect, is today's substitute for Althesin, removed overnight from the National Formulary.)

Now consider inpatient surgery with a muscle relaxant and automatic ventilation of the lungs (for example, cataract surgery, cholecystectomy). The mean cost of propofol as the induction agent ($n = 3200$) would be about 1.26 times the mean cost of thiopentone (Table 2).

Dr McWilliam's failure to cost carrier gases and volatile agents should surprise no one; it is a fiendishly convoluted exercise but, with that caveat, the Tables suggest an isoflurane anaesthetic for day surgery in this hospital might cost 2.2–3.3 times as much as a halothane or opioid anaesthetic; and for inpatient surgery 1.6–1.8 times as much.

Anaesthetic agents are relatively cheap. For instance, in cataract surgery the lens costs £80.00–100.00 and artificial vitreous humor (Healonid) £30.00. Drugs, the tools of our trade, comprise a small part (but how small?) of the 'non-pay' costs of anaesthesia. Clearly, we should not dismiss them as totally irrelevant; given the incentive to save money on drugs, assuming that were possible, we should be allowed to spend it on other things which might improve

Table 1. Average drug costs for day-case general anaesthesia $n = 1600$. (VAT at 15%) 1 MAC volatile agent.

	Thiopentone induction	Propofol induction	Factor (increased cost with propofol)
Cost with halothane or opioid*	£1.90 (£2.18)	£3.66 (£4.20)	×1.93
Cost with isoflurane	£6.26 (£7.20)	£8.02 (£9.22)	×1.28
Increased cost with isoflurane	×3.3	×2.2	

*Fentanyl 100 μg or alfentanil 310 μg.

Note Thiopentone 4 mg/kg £0.41; propofol 2 mg/kg £2.17; nitrous oxide:oxygen 7:3 £0.75; isoflurane £4.60; halothane £0.22; opioid £0.22; intravenous cannula £0.52. To obtain the cost of an enflurane anaesthetic, subtract the cost of isoflurane or halothane and add £2.20.

Table 2. Average drugs costs for inpatient (relaxant) general anaesthesia. $n = 3200$. (VAT at 15%) 1 MAC volatile agent.

	Thiopentone induction	Propofol induction	Factgor (increased cost with propofol)
Cost with halothane	£5.42 (£6.23)	£7.18 (£8.26)	×1.32
Cost with isoflurane	£9.90 (£11.27)	£11.56 (£13.29)	×1.18
Cost with opioid*	£6.22 (£7.15)	£7.98 (£9.18)	×1.28
Increased cost with isoflurane	×1.8	×1.6	

*Fentanyl 500 μg.

Note Add to costs in Table 1: opioid £0.80; alcuronium 20 mg £1.04; atropine 1.2 mg £0.15; neostigmine 2.5 mg £0.07; intravenous infusion set £1.24; 1 litre compound sodium lactate solution £0.82.

the safety and comfort of patients. The fallacy is: if we do save money that is the last we see of it.

Drug costs in anaesthesia are truly irrelevant in one important sense. The anaesthetist is duty bound to use any agents, no matter how expensive which, in his (her) hands, give the best results. The physical state of general anaesthesia is as close to death as a doctor deliberately contracts to bring a patient, so only the best results will do.

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Blackout during cardiopulmonary bypass

Cardiopulmonary bypass is now undertaken routinely for coronary artery surgery; 1000 are carried out in this hospital each year. The mortality for this operation is under 1%.

However, while two patients had elective cardiopulmonary bypass during coronary artery surgery we had, what must be in this day of advanced technology, an extremely rare and potentially disastrous event: a total power failure without any warning!

The hospital was without any electricity for 18 minutes. A mains power failure at the North Western Electricity Board had disconnected the hospital and surrounding regions. The hospital's emergency generator, which should have taken over instantaneously, came on after some delay and then failed. The hospital was without electrical power first of all for 2 minutes and two periods of 8 minutes. We had no monitoring apparatus of any kind during this time and the bypass machines had to be hand-cranked to maintain perfusion. The perfusionists hand-cranked to the line pressure previously noted on their aneroid gauge and the anaesthetists ventilated the lungs with 100% oxygen by hand. Both patients were already cooled to 26° Celsius and both pumps are fitted with oxygen sensors which are battery powered. No other form of monitoring or temperature control was immediately available. A further assistant was required to hand-crank the pump suction because it is difficult to crank at two different speeds with each hand.

We are lucky in that our theatres have proper windows which allow daylight because the anaesthetic rooms were in total darkness. Torchlight was used in addition.

Both operations proceeded at an unprecedented speed but without undue panic in spite of these conditions. Both patients were rewarmed rapidly once the power was restored since the electricians could not guarantee the supply. Both patients came off bypass easily and had an uneventful postoperative course with no evidence of neurological sequelae.

We recommend that each theatre should have rapid access to battery powered monitors, usually used for the transfer of critically ill patients and that the current practice of totally enclosed, windowless theatres be abandoned, not only for the wellbeing of the theatre personnel but, as in this case, also for the patients' wellbeing.

Serious discussions have taken place with the engineers to ensure the continuity of the supply in the future.

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Heparin and heparin–saline: another hazard

Recently a surgeon noted that the blood in the arterial cannula had clotted immediately before cardiopulmonary bypass was started. A careful check showed my assistant had accidentally handed me a 20-ml syringe with heparin–saline solution rather than heparin. Neither of us noted the mistake, which was partly attributable to the fact that heparin–saline solution is not normally supplied to this operating suite.

The manufacturers are not sympathetic to my suggestion that heparin–saline boxes and ampoules should be prominently marked with, say, a diagonal black line. They reply with the patently obvious argument one should always be careful and that furthermore such an alteration would, surprisingly, require the approval of the Department of Health.

It is a truism that if a mistake or accident can happen, sooner or later it will happen, and this is one reason for the explosive development of real time noninvasive monitoring. This near-catastrophe supports a common practice of measuring the clotting time after the administration of heparin in cardiac surgery. One centre has even gone to the extreme of ordering heparin and protamine sulphate solutions from different manufacturers to avoid confusion between similarly coloured 5-ml ampoules, whatever arguments may be paraded about being careful and reading labels!

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Anaesthetists as physicians

Dr Jones advocates the archaic use of the word physician to describe those practitioners of the healing art who are legally qualified in both medicine and surgery (*Anaesthesia* 1989; **44:** 794), which would thus include anaesthetists and surgeons. Perhaps he can suggest a collective noun to refer to healers in such specialties as cardiology, gastroenterology, rheumatology, dermatology and the like, who see themselves as forming a group sufficiently distinct from anaesthetists and surgeons to have even formed their own Royal College.

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A paediatric orotracheal tube with laryngeal hooks

Tracheal tube placement and fixation is recognised to be a problem in paediatric anaesthetic practice. Unintentional bronchial intubation is a common mishap because a newborn infant's trachea measures only 4 cm in length, and increases to 5 cm by 2–3 years of age.[1] Movement of an infant's head and neck can significantly alter the position of a tracheal tube's tip.[2]

Adaptations in tracheal tube design may reduce the incidence of such a problem. Markers at the distal end of a tube help. The compound tube of the Cole pattern is another simple solution.[3] However, the flow resistance of the Cole tube is greater than that of the plain tube.[4] There is also a risk of laryngeal dilatation with prolonged use of a Cole tube.[5] The preformed anatomical tube is another potential aid.[6–8] It is still quite possible to mismatch a preformed or precut tube with a particular patient.

Laryngeal hooks were suggested as an aid to the placement of cuffed tracheal tubes.[9] It is now proposed that lugs might be attached to the lateral walls of plain paediatric tubes with the same intent. Blunt, atraumatic lugs are fixed to either side of a standard plain Magill pattern tracheal tube about 2 cm from the distal tip (Fig. 1). These projections are fixed at right angles to the tube's long axis, are about equal in length to the tube's external diameter and are angled somewhat posteriorly in direction. They are formed in a single stamping from a sheet of polyvinyl chloride which is bonded to a standard latex tube and were made by Mr W. Donald of the Highland Health Board's Department of Bio-Engineering. A reasonable degree of care should be exercised in placement since such a tube should obviously not be forced beyond the cords.

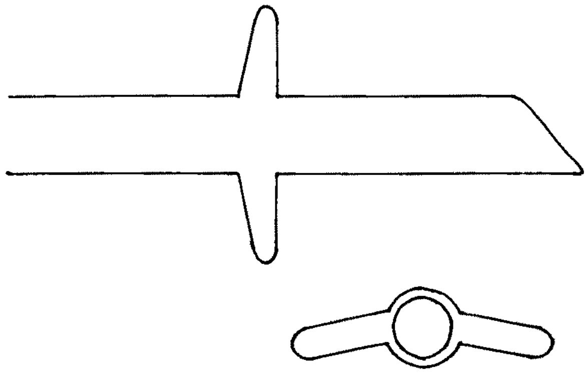

Fig. 1. Plain paediatric tracheal tube with laryngeal lugs.

It is hoped that such a design might be of value in paediatric anaesthesia and resuscitation.

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Failure of oxygen flush device

A Cape Waine (Mk III) anaesthetic ventilator was serviced one week before the malfunction which is described below: no fault was detected by the engineer at this time.

A routine check was done with the cylinder gas supply of oxygen and nitrous oxide. The oxygen failure device worked satisfactorily. The drill was repeated with the pipeline gas supply and the pressure gauge indicated pipeline pressure of 3.5 bar for oxygen and 4.2 bar for nitrous oxide.

A flow rate of 4 litres/minute was set for oxygen. When the oxygen flush was pressed the oxygen failure device was activated and resulted in cessation of the oxygen flow at the common gas outlet and nitrous oxide was vented to atmosphere. The connexions at the Schrader and the hosepipe union block were checked and found to be well secured. There was no audible leak from any part of the ventilator or the breathing system. No crack was visible in the flowmeters. All tests for leak were negative.

The service engineer conducted a thorough examination and found a faulty nonreturn valve at the oxygen hosepipe union block. The valve did not seat properly and obstructed high flow of oxygen. Use of the oxygen flush required a flow great enough to cause a decrease in the oxygen pressure-activated failure device. This device in the Cape Waine (Mk III) cuts off the nitrous oxide supply and vents it to atmosphere before it reaches common fresh gas outlet: thus there was no gas flow at the common gas outlet.

Most anaesthetists have a routine for checking anaesthesia apparatus before anaesthesia is started. There is surely now a need for a chart in induction rooms, or better still, attached to the anaesthetic machine. This would be useful for the Operating Department Assistant or Anaesthetic Nurse, and for junior and senior anaesthetists.

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Editor's note. Readers should be aware that the Association of Anaesthetists of Great Britain and Ireland have established a working party to design a practical check list for regular use by anaesthetists. If you have an opinion about this which you would like to be considered please do not hesitate to write to the Honorary Secretary of the Association and express it.

The sterility of lubricant jelly used on tracheal tubes

It is common practice to use sterile tracheal tubes for intubation but these are often coated with a water-soluble lubricant jelly before use. This lubricant is either supplied in multi-use tubes such as KY Jelly (manufactured by Johnson and Johnson Patient Care Ltd, Coronation Rd, Ascott, Berks) or in sterile single-use sachets (like those produced by Phoenix Pharmaceuticals Ltd, Gloucester). We decided to examine the contents of the multi-use tubes to determine their safety for repeated use or if they are a potential source of infection of the trachea.

Twenty-five tubes of KY jelly were used for tracheal tube lubrication in a general theatre suite over a period of about one month. The tubes were used either once, five, or 10 times (see Table 1) before dispatch for culture.

Table 1.

Number of times tube used	Number of Tubes tested	Mean period of use (days)	Micro-organisms isolated
1	5	1.0	Two grew *Staphylococcus albus*
5	5	1.6	One grew *Staphylococcus albus*
10	15	3.2	No growth

Swabs were taken from the necks and caps of the tubes and cultured on blood, Maconkey and Sabauraud's agar both aerobically and anaerobically. Meanwhile a 10-g sample of lubricant jelly was squeezed into 10 ml of Robertson's cooked meat broth mixed and innoculated onto blood agar plates for aerobic and anaerobic culture in order to perform colony counts after 24 and 48 hours' incubation. The rest of the broth culture was then incubated and sampled at 2 and 7 days for aerobic and anaerobic growth. All but three of the samples showed no growth in any of these cultures. Those that were positive grew only insignificant numbers of a coagulase negative *Staphylococcus albus*. It is particularly important to note that despite this extensive microbiological screening no gram-negative organisms (including pseudomonas) or streptococci were isolated.

The cost of using multi-use tubes of lubricant jelly (assuming a conservative 10 uses per tube) is less than half that of single-use sachets; they are more convenient in use, and as we have shown, they do not present a vehicle for infection of the trachea. We therefore recommend the continued use of tubes of lubricant in preference to sachets.

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Anaethesia, 1990, Volume 45, pages 178–184

Anaesthetic literature

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The collator of this section is Dr L. Kaufman, MD, FFARCS, 145 Harley Street, London W1N 2DE. Dr Kaufman is prepared to provide on request, and at a modest charge, a new additional service to our readers. References from January 1984 have been entered on data base. The data are held on Dbase II, cpm 86 and on Dbase II, MsDos and are available on disc, together with a program providing search facilities. Enquiries direct to Dr Kaufman at the above address please.

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Anaesthesia, 1990, Volume 45, page 185

Safety Action Bulletin

Anaesthetic and respiratory equipment: the use of 20-mm breathing system connexions (SAB) 89 (78)

This announces an internationally agreed change designed to improve the security of 22-mm connexions and reduce their number. It embodies the need to abandon the defined male/female sequence of fittings. Implementation may result in some incompatibilities.

Health Authorities are advised to organise a planned change to the new system to avoid the hazard of disconnexion and misconnexion. The British Anaesthetic and Respiratory Equipment Manufacturers' Association (BAREMA) are prepared to advise about the availability and suitability of equipment supplied by its members. Enquiries should be directed to the Secretary, Mr B. R. Sugg, The Stables, Sugworth Road, Randley, Oxford, OX14 2HX (Tel: 0865 736393).

Erratum

Anaesthesia, 1989, Volume 44, pages 982–983

Oropharyngeal volumes

G. N. NEWCOMBE AND W. J. RUSSELL

The second sentence of the summary should read:

The volume that encompasses 99% of the normal population is estimated as 215 ml if the assumption of a normal Gaussian distribution is made, or 342 ml if a log-normal distribution is assumed.

In the penultimate paragraph before the Acknowledgments, the fifth sentence should read:

The mean value is 78.3 ml with a 2 SD spread of 24.5 to 249.6 ml or a 2.54 SD spread of 17.9 to 342 ml if a log-normal distribution is used, which corrects the skewed distribution and avoids negative values.

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Examples of correct form of references
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JOURNAL

Standard journal article—(List all authors)
Soter NA, Wasserman SI, Austen KF. Cold urticaria: release into the circulation of histamine and eosinophil chemotactic factor of anaphylaxis during cold challenge. *New England Journal of Medicine* 1976; **294:** 687–90.

Corporate author
The Committee on Enzymes of the Scandinavian Society for Clinical Chemistry and Clinical Physiology. Recommended method for the determination of gamma-glutamyltransferase in blood. *Scandinavian Journal of Clinical Laboratory Investigation* 1976; **36:** 119–25.
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Personal author(s)
Osler AG. *Complement: mechanisms and functions.* New York: Prentice-Hall, 1976.

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American Medical Association Department of Drugs. AMA drug evaluations, 3rd edn. New York: Publishing Sciences Group, 1977.

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OTHER ARTICLES

Newspaper article
Shaffer RA. Advances in chemistry are starting to unlock mysteries of the brain: discoveries could help to cure alcoholism and insomnia, explain mental illness. How the messengers work. *Wall Street Journal* 1977 Aug 12: 1(col 1), 10(col 1).

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Roueche B. Annals of medicine: the Santa Claus culture. *The New Yorker* 1971 Sept 4: 66–81.

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REVIEW JOURNALS

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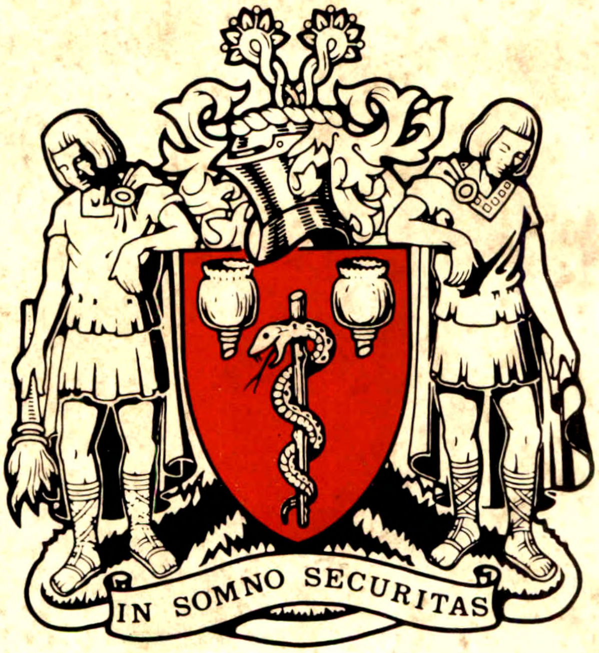

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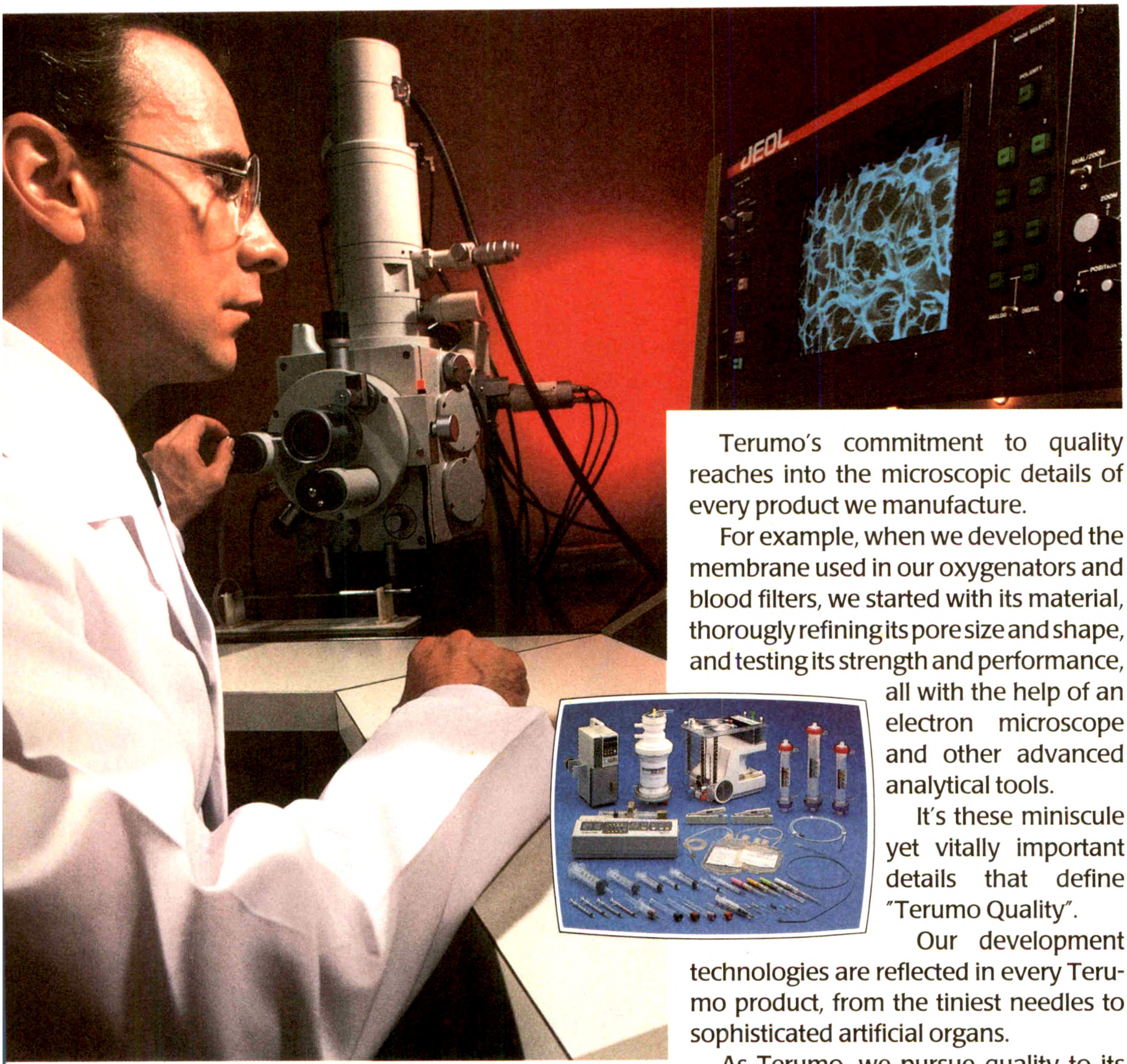

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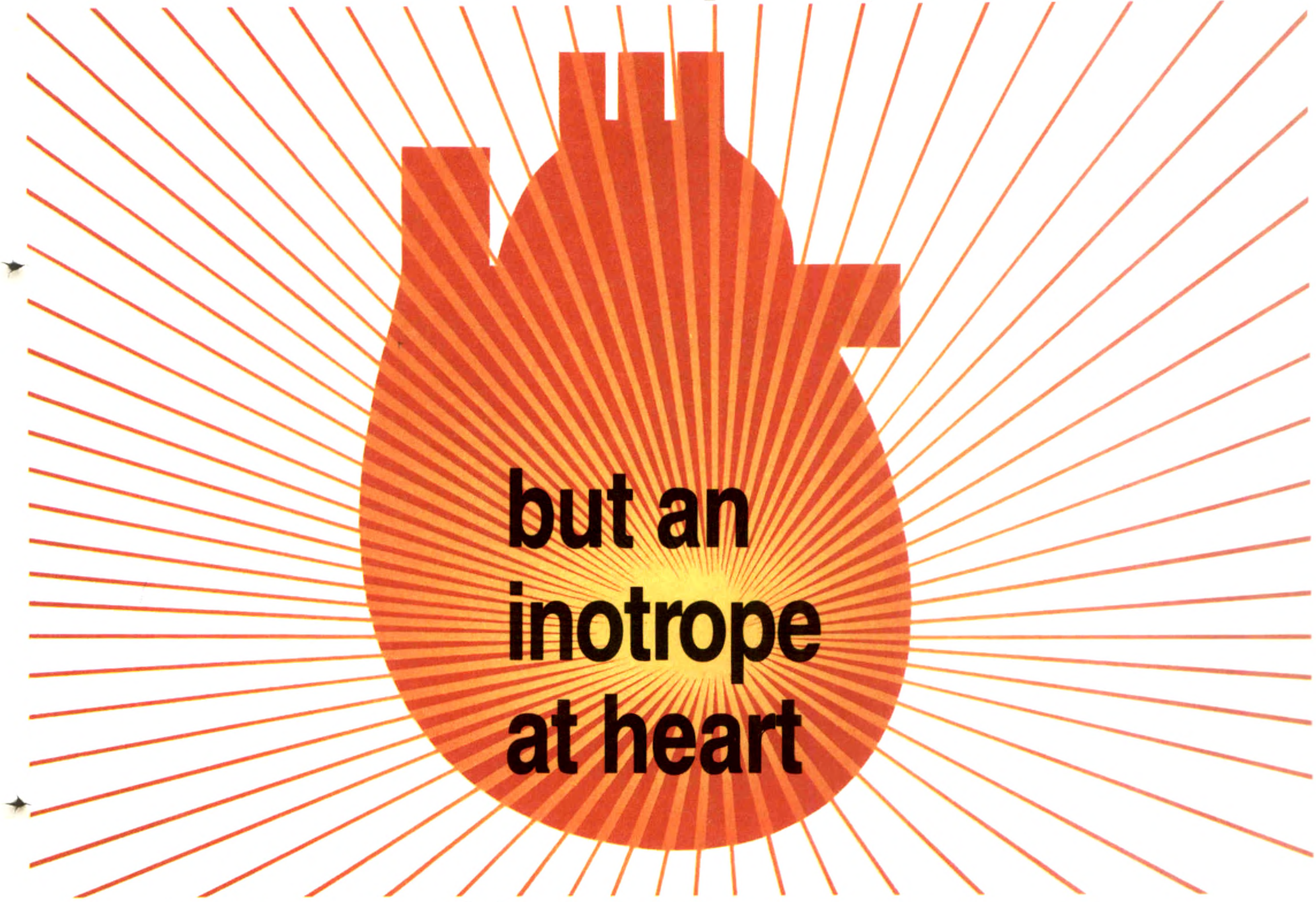

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References

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3. *J Am Coll Cardiol* 1987; **10** (6): 1294-1302
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8. *N Eng J Med* 1983; **309** (13): 748-756
9. *Circulation* 1985; **71** (5): 972-979

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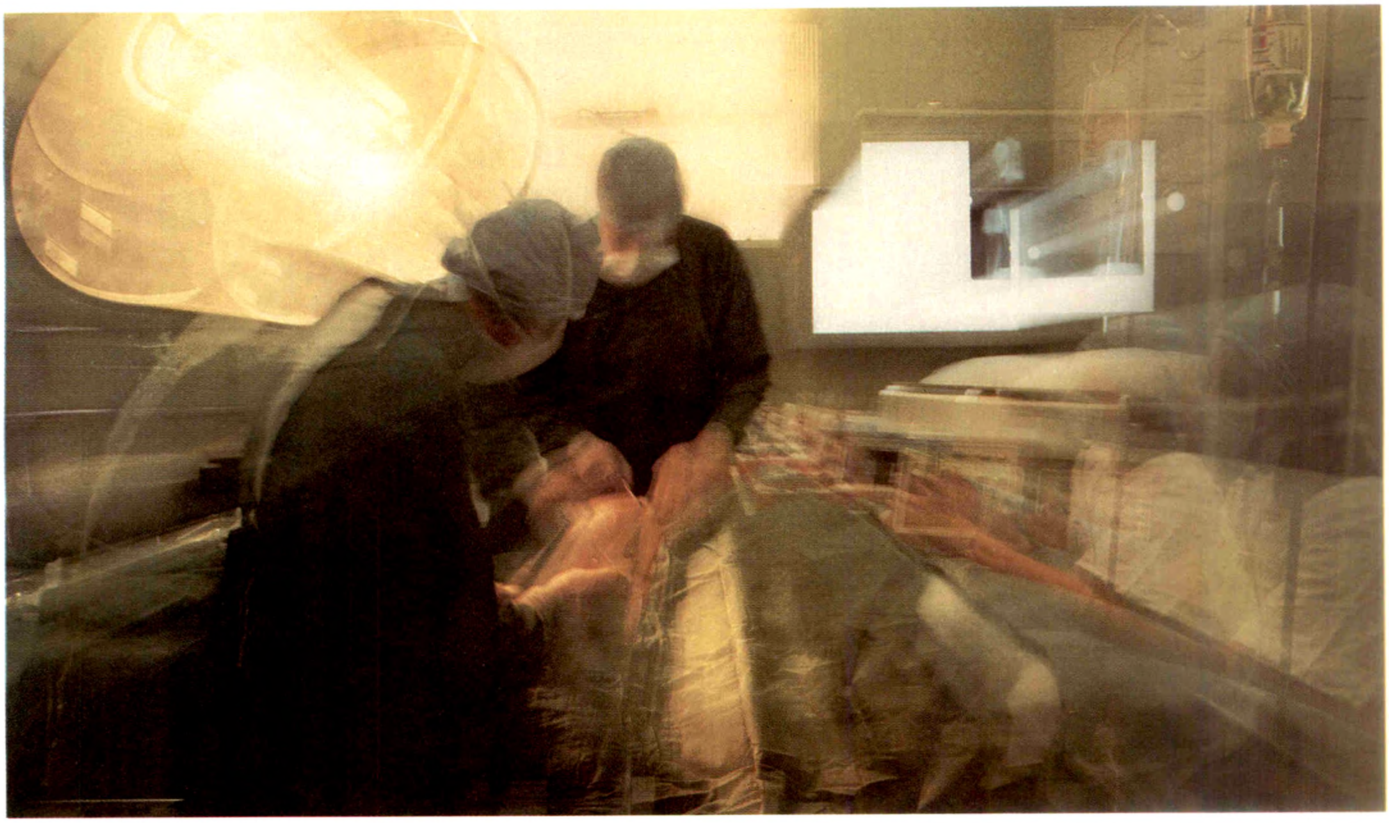

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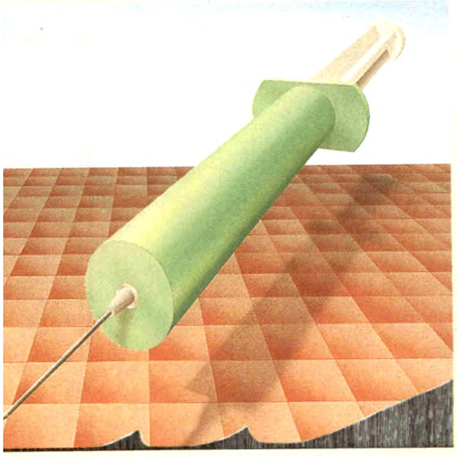

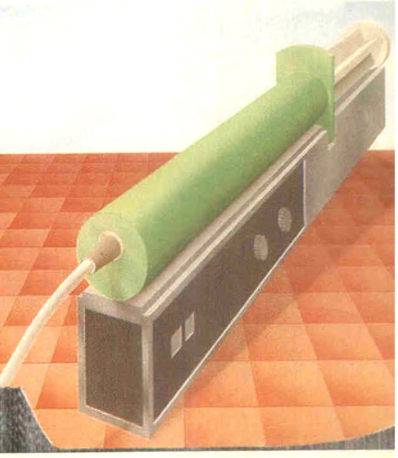

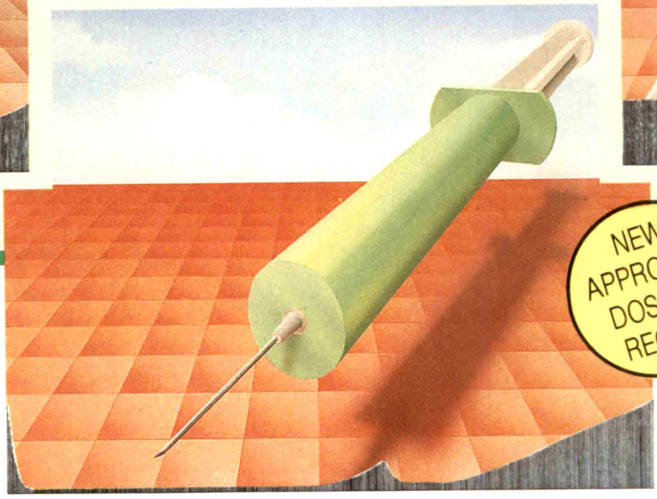

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Anaesthesia, 1990, Volume 45, pages 187–188

Editorial

Chaos in anaesthesia

Biologists have never been under the illusion that theirs was a science as exact as physics, and as clinicians we know that patients often get better despite us rather than because of us. None the less there is an underlying hope that in the future our increased knowledge will enable us to predict the outcome of disease for a particular patient with a reasonable degree of certainty.

Developments in mathematics and physics in the last 15 years may mean we need to revise this philosophy.

There are plenty of questions anaesthetists would like to answer. Which patient with underlying coronary ischaemia will suffer a myocardial infarction in the perioperative period? Which patient with pre-existing disease of the respiratory system will require prolonged ventilation of the lungs postoperatively, and which patient will be impossible to wean from artificial ventilation? Which patient will suffer a stroke after carotid endarterectomy? How can we foretell that the most recent admission to the intensive care unit is not going to survive despite maximal treatment? The benefits of being able to answer these questions are obvious.

For some years we have placed much confidence in the ability of the computer to manipulate large quantities of data. It seems intuitively obvious that if we can measure more and more variables, measure each of them more and more accurately, and submit them to the correct complex statistical analysis, then surely we must be able to predict individual outcome with some certainty. That is what the meteorologists thought about modelling the weather, but they were wrong.[1] Our intuition is probably wrong too, and for the same reason: *chaos*.

Scientists have been diverging since experimental science began. There has been some cross-fertilisation between subjects but no new unifying theory which is important to all subjects. Coincident with the development of the digital computer in the 60s and 70s, and because of it, mathematicians and physicists began to explore the behaviour of nonlinear systems, that is systems for which the output depends on some function of the input that is more complex than $y = kx$ or similar function. The other feature of the systems was that they were iterative: the output was itself the input for the next state of the system. The exact form of the systems that were explored does not matter because the behaviour was the same no matter what the nonlinear system: if certain scaling parameters were manipulated, the output of the systems became apparently unpredictable. And in the approach to unpredictability, the behaviour of all systems was the same. First there was ordered development of oscillations in output, termed 'period doubling'. Secondly, beyond a critical value of the parameter the output of the system became chaotic. Thirdly, the exact value of the parameter at which a system became chaotic was undefinable; no matter how much the boundary between order and chaos was magnified, no clear dividing line emerged.

The mathematicians studied pure equations; the physicists studied physical systems such as convection and turbulence. The same observations emerged of period doubling and progression to chaos.

The infinite detail generated by nonlinear dynamics is best illustrated by the behaviour of the equation $z \rightarrow z^2+c$, (the next value of z is the square of its current value, to which is added the constant c). Both z and c are complex numbers but an understanding of complex numbers is not required to appreciate the outcome of the repeated solution of the equation. The resulting structure, named the Mandelbrot set after its discoverer, is the most complex mathematical object ever discovered, yet is generated by this absurdly simple equation. The pictures of its deeper structure, and of the Julia sets to which it forms a catalogue, are extraordinarily beautiful.[2,3] This is pure mathematical theory. It is not biology although it is an excellent introduction to a feeling for what chaos is about.

The theoretical biologist, Robert May, wrote a paper in 1976 that is now a classic in chaos theory.[4] Suppose that this year, year *n*, there is a population of insects p_n, where p is between 0 and 1. Next year, year *n+1*, the population will be larger if there are more insects available to breed, $p_{n+1} \propto p_n$; but smaller because there will be less food, $p_{n+1} \propto (1-p_n)$. The resulting equation, $p_{n+1} = C.p_n(1-p_n)$, is simple, yet as C is increased beyond 3.6 it exhibits extremely complex behaviour. It is neither random, which implies uniform distribution, nor is it variable about a mean. The behaviour is actually absolutely deterministic but to all intents and purposes it is chaotic.

The behaviour of real insect populations follows May's predictions. Extensions of them have been applied to mixed populations of predators and prey. Glycolysis and the membrane potentials of excitable tissues show chaotic behaviour, at the other extreme. It has also been shown in the endocrine system, the haematopoietic system, and in breathing. An early paper, which discussed ventilatory oscillations and oscillations in white cell counts in leukaemia, was that of Glass and Mackay.[5] A useful source text for the physiological applications of chaos theory is Rapp's chapter in the book edited by Holden.[6] Many of the investigators were at a recent meeting of the American Association for the Advancement of Science, reported briefly in the *British Medical Journal.*[7]

One of the features of a system in chaos is extreme sensitivity to the starting values. A computer program to explore the behaviour of May's equation is only a few lines of code. There are plenty of illustrations of the behaviour in the books on the subject, and Hofstadter gives a clear account,[8] but it is instructive to watch the process. The behaviour when $C = 3.80074$ cannot be predicted from watching the behaviour when $C = 3.80073$. There are no physical variables that can be measured with this accuracy, far less any biological ones.

There is predictability in the progression to chaos.

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The ratio that governs the occurrence of the next period doubling, whether the system is mathematical, physical, biological, and possibly even macro-economic, is a universal constant, the Feigenbaum number, and in the limit it is 4.669201660910... It is as important as *pi* or *e*.

It is a truism to state that biological systems are complex, and that modelling them requires numerous simultaneous equations. What is not so apparent is that even simple systems can generate exceedingly complex behaviour, behaviour that cannot be predicted from observation of prior behaviour.

The full implications of the relevance of chaos theory to biology are not known. The science of chaos is relatively young but given the ease of modern communications it is surprising that the applied sciences, in which anaesthesia is included, have paid it so little attention. Anybody researching a control system should know about it. If chaos can be demonstrated in molecular systems like glycolysis, what are the implications for interactions at receptors or for the process of general anaesthesia itself?

On a more immediately practical level there are two lessons. First, that awkward outlier, which tends so often to be ignored in statistical analysis, may be the most interesting observation because it is at least possible that this outlier is indicative of the onset of chaos in the system under examination. Second, complex models, whether of physiological or pathological processes, may be no better at predicting outcome than simple ones, not because we need more information, but because it is inherently so. We may have to remain satisfied with having to make predictions for populations rather than for individuals, though we will still be able to make predictions for individuals based on probabilistic estimations, even if the systems are chaotic.[7]

In 1976 May wrote this later much quoted statement: '...we would all be better off if more people realised that simple nonlinear systems do not necessarily possess simple dynamical properties.' Chaos is universal.[9] Our control systems must have developed either to include it or to exclude it, perhaps both. We must be aware of it.

N. W. Goodman

Southmead Hospital,
Bristol BS10 5NB

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Anaesthesia, 1990, Volume 45, pages 189–197

Pregnanolone emulsion

A preliminary pharmacokinetic and pharmacodynamic study of a new intravenous anaesthetic agent

P. CARL, S. HØGSKILDE, J. W. NIELSEN, M. B. SØRENSEN, M. LINDHOLM, B. KARLEN AND T. BÄCKSTRØM

Summary

Pregnanolone emulsion, a new steroid anaesthetic agent, was administered intravenously as bolus doses to six young healthy male volunteers in a preliminary pharmacokinetic and pharmacodynamic study. The plasma concentration-time curves fitted a two-compartment model. The elimination half-life was between 0.9 and 1.4 hours, volume of central compartment between 0.95 and 2.10 litres/kg, volume of distribution between 3.75 and 5.58 litres/kg and total body clearance between 1.80 and 3.07 (litres/hour)/kg. The excretion in urine of unchanged pregnanolone was less than 0.1%. The pharmacodynamic properties were found to be similar to those of Althesin, with immediate induction of anaesthesia of short duration. The anaesthetic affected haemodynamics only slightly; minor depression of ventilation, with an increase in $Pa\text{CO}_2$, *occurred in several of the subjects. Excitation of short duration occurred in one subject during induction of sleep and slight involuntary muscle movements in another subject during sleep. It is impossible to draw any clear conclusions of the clinical efficacy and tolerance from this limited normal subject trial, but pregnanolone emulsion seems worthy of further clinical trial.*

Key words

Anaesthetics, intravenous; pregnanolone.
Pharmacokinetics.

Figdor *et al.*[1] demonstrated in 1957 that a series of structurally related pregnanes, without notable endocrine action, were anaesthetically active when administered to mice. The most active of these pregnanes was pregnanolone (3α-hydroxy-5β-pregnane-20-one), which is a naturally occurring metabolite of progesterone, first isolated from urine of pregnant women in 1937.[2] The anaesthetic effect of pregnanolone has been demonstrated in several animal species,[3] but its lack of water solubility prevented its development in clinical practice. Pregnanolone is now prepared in a stable emulsion which may prove to be suitable for clinical use. It is solubilised in soya bean oil and emulsified in a similar way to diazepam in the form of Diazemuls.

A wide species variation in toxicity and tolerance of pregnanolone emulsion was observed in preclinical studies. Administration of a single bolus injection of 40 mg/kg did not cause any (or only marginal) mortality in the mouse and the rat. No organ toxicity was noted after repeated daily intravenous injections in several species: rat 16 mg/kg for 4 days and 7 mg/kg for 28 days; dog 12 mg/kg for 4 days and 3 mg/kg for 28 days; monkey 28 mg/kg for 14 days and 21 mg/kg for 28 days. Hepatic lesions restricted to the biliary system, manifested as morphological changes and increased serum enzymes, occurred after daily administration of 40–64 mg/kg for 4 days and after 14 mg/kg for 28 days in the rat. In the dog the threshold dose for hepatobiliary changes at repeated doses was about 7 mg/kg. The liver damage was clearly related to the dose, but also to the duration of the treatment, and was reversible at least in its initial state (toxicological report, not published). The anaesthetic and anticonvulsive properties of pregnanolone in animals are encouraging and very similar to those of Althesin.[4–6]

This study reports the findings of a preliminary and limited clinical investigation with pregnanolone emulsion in male volunteers.

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Methods

Six healthy male volunteers with no past history of earlier anaesthetic complication, allergy to drugs or abuse of alcohol or drugs took part in the study. The trial was conducted in accordance with the Helsinki II Declaration and approved by the local ethics committee.

The experiment was explained to the volunteers and preliminary consent obtained. The subjects were then submitted to a complete physical examination and laboratory tests, in which a variation of 10% above or below the normal range of the laboratory data was allowed. The subjects were asked to report on the morning of the study fasted and completely rested.

The radial artery was cannulated percutaneously using a 20-gauge catheter. Arterial cannulation was performed in the nondominant limb and only in the presence of a competent ulnar artery. A systemic arterial catheter was connected via a pressure transducer calibrated with water standards to a two-channel multiparameter monitor, and the systemic arterial blood pressure was recorded continuously. A peripheral vein was cannulated in the contralateral arm for electrolyte solution and drug administration. Continuous electrocardiogram (ECG) using chest electrodes, pulse monitoring and central (rectal) and skin (toe) temperature were instituted. These variables were also charted continuously. Respiratory rate was measured at one-minute intervals.

The subjects were then allowed to rest for one hour in the supine position after which baseline recordings were made. Pregnanolone emulsion (PE) was formulated as pregnanolone 4 mg, soya bean oil 200 mg, acetyl triglycerides 70 mg, egg yolk phosphatides 18 mg, glycerol 17 mg and with distilled water to a volume of 1 ml. The emulsion was isotonic, stable and had a pH of about 7.5. The mean particle size was 0.2–0.5 μm and less than 3% of particles were larger than 1.0 μm. The volunteers received two bolus doses of PE, with an interval of at least 2 weeks between the first and the second doses. The initial dosage of 0.05 mg/kg was chosen from consideration of data obtained in toxicological studies. The study was sequential, i.e. increasing doses in consecutive subjects until anaesthesia was induced for about 10 minutes or until a maximum dose of 1.6 mg/kg or unacceptable side effects were observed. Pregnanolone concentration was determined in arterial blood before injection and then at 5, 10, 20, 30, 40 and 50 minutes and at 1, 1.5, 2, 2.5, 3 and 4 hours after the start of injection of the anaesthetic. The blood samples were centrifuged (1000 rpm for 5 minutes), frozen at −20°C and kept at this temperature until analysis. Urine samples were collected for 0–12 and 12–24 hours after administration of PE 0.3 mg/kg and higher doses, and then stored at −20°C.

The following analyses were performed on blood samples to assess the effects on hepatic function and haematology: haemoglobin, sodium, potassium and creatinine concentrations, white cell count and platelet count (prior to induction and at 8, 12 and 24 hours); bilirubin, alkaline phosphatase and aspartate amino transferase (ASAT) concentrations (prior to induction and at 8, 12 and 24 hours); triglyceride, cholesterol and free fatty acid concentrations (prior to induction, immediately after administration, and at 1 and 24 hours); arterial blood gas tensions (prior to induction and at 2, 5, 10, 15, 30 and 60 minutes).

Observations

Induction time. At the start of injection, the subjects started to count and the times to stop counting, drop a syringe of water held 90° from the body and lose the eyelash reflex were noted.

Sleeping time. The time from loss to return of eyelash reflex was noted.

Recovery from anaesthesia. This was assessed by measurement of the times from the end of the injection to return of eyelash reflex, spontaneous opening of the eyes on command (waking time), first verbal response, full orientation in time and space and a subjective experience of being unaffected by pregnanolone.

Undesirable effects. Involuntary muscle movements, excitation, hiccough, cough, laryngospasm, upper airway obstruction, apnoea, and necessity for artificial ventilation or oxygen supplementation were noted.

Effects on blood vessels used for injection. Pain on injection, redness, tenderness, induration and thrombophlebitis were sought and noted. The length of redness and tenderness was expressed in cm. The site of injection was examined 24 hours and one week after injection of PE.

A follow-up visit was scheduled one week after the study for a further physical examination, laboratory tests and detection of any delayed problems.

Analytical technique

The analytical method for assaying blood and urine concentrations was based on combined gas chromatography–mass spectrometry (Hewlett Packard mass selective detector 5979B). The gas chromatograph (HP 5890) was equipped with a capillary column injection system and interfaced with an HP data acquisition system. Separation was performed on an SE-54 fused silica capillary column (Hewlett Packard, 25 m, 0.2 mm i.d., 0.1 μg phase thickness). The injector was operated in the splitless mode for 30 seconds at 280°C. The temperature of the oven at the start was 120°C; programmed to increase at 50°C/minute to 280°C and then held isothermal for 2.5 minutes. The carrier gas was helium (1 ml/minute) and the column was directly interfaced to the ion source. The mass spectrometer was operated in single ion mode at 12 cycles/second, with a 0.25 second dwell time, monitoring m/z 300 for both pregnanolone and the internal standard.

The method comprised extraction from 0.01–1 ml plasma with 3 ml diethyl ether/hexane (1/2) at pH 13 (3 ml 0.2 mol/litre aqueous NaOH) of unconjugated pregnanolone directly and of total (unconjugated and conjugated) pregnanolone after previous hydrolysis with glucuronidase (sulphatase). The dried (anhydrous Na_2SO_4) and evaporated extract was derivatised by 50 μl N, O-bis (trimethylsilyl) triflouroacetamide and 10 μl dry triethylamine at 85°C for 15 minutes to give the 3-hydroxy-trimethylsilyl derivatives of pregnanolone and the internal standard 3β-hydroxy-5α-pregnanolone-(20). The derivatives were chromatographed by capillary gas chromatography, and on electron impact of the eluent peaks the m/z ion 300 trace was monitored and quantified for both compounds. Accuracy (recovery) tested on spiked serum samples in the range 4–400 μg/litre varied between 95 and 106%. Between-day variation estimated for one sample and using different calibration curves was 3.9% at a concentration of 444 μg/litre. Limit of sensitivity was set to 5 μg/litre.

The assay method also allows for analysis of the total amount of pregnanolone after previous hydrolysis of conjugates with glucuronidase. An estimate of conjugated pregnanolone was calculated by subtracting the amount of unconjugated pregnanolone obtained on direct extraction of the sample. The amounts are expressed as pregnanolone equivalents in μg mass.

Kinetic analysis

Each plasma pregnanolone-time profile using an unweighted nonlinear regression programme was individually fitted to the following two-compartment model:

$$C = A \cdot e^{-\alpha t} + B \cdot e^{-\beta t}$$

C = pregnanolone plasma concentration (μg/litre) at any time (t) in hours; A = intercept at $t = 0$ for distribution phase (μg/litre); α = distribution rate constant (1/hour); B = intercept at $t = 0$ for elimination phase (μg/litre); β = elimination rate constant (1/hour).

The area under the concentration-time curve to 4 hours (AUC_{0-4}) was calculated by the trapezoidal method, and residual area ($AUC_{4-\infty}$) by dividing the fitted concentration at 4 hours by β. Cl_{tot}, the total body clearance [(litre/hour)/kg)], was obtained by dividing the dose by $AUC_{0-\infty}$; Vc (volume of the central compartment in litre/kg) was obtained by dividing the dose by $A+B$. The volume of distribution (V_d; litre/kg) was obtained by dividing Cl_{tot} by β.

Results

Dosage of PE covered a range of 0.05–0.6 mg/kg. Induction of sleep was achieved at a dose of 0.4 mg/kg and the protocol was changed according to Table 1 which shows the weight of the subjects and dosages employed. Subject number 5 received only one dose of PE because of paraesthesia in the hand several days after removal of the arterial cannula. Subject number 6 was excluded from study period 2 after admitting that he had been working through the previous night.

Table 1. Details of subjects and intravenous doses of pregnanolone administered as an emulsion formulation (mg/kg and total dose in ml).

Subject number	Administration	Weight (kg)	Dose (mg/kg)	Total dose (ml)
1	1	70	0.05	0.9
	2		0.50	8.8
2	1	80	0.15	2.9
	2		0.40	7.7
3	1	70	0.40	7.0
	2		0.30	5.3
4	1	74	0.60	11.1
	2		0.50	9.3
5	1	86	0.60	12.9
6	1	92	0.60	13.8

Pharmacokinetics

Plasma concentrations of total and conjugated pregnanolone are shown in Tables 2 and 3. Very low concentrations were expected after doses up to 0.3 mg/kg, and plasma was sampled only 5 and 8 minutes after administration of PE in subjects 1, 2 and 3 in study period 1. Thus no pharmacokinetics could be derived from these treatments. Figure 1 shows the serum concentration-time curve of unconjugated and conjugated pregnanolone (subject 4) after injection of PE 0.5 mg/kg. The pharmacokinetic variables computed from the plasma pregnanolone concentrations are listed in Table 4. The two-compartment model fitted the data well and suggests a distribution phase with $t_{\frac{1}{2}\alpha}$ varying between 9 and 15 minutes and the corresponding elimination half lives ($t_{\frac{1}{2}\beta}$) between 0.9 and 1.4 hours. The volume of the central compartment (V_c) varied between 0.95 and 2.10 litres/kg and that of the total compartment (V_d) between 3.75 and 5.58 litres/kg. Total body clearance (V_{tot}) was calculated between 1.80 and 3.07 (litre/hour)/kg; excretion in urine of unconjugated pregnanolone accounted for negligible amounts (less than 0.1%). The total amounts of conjugated pregnanolone excreted in urine corresponded to about 10% of the dose (range 7.9–16.2%).

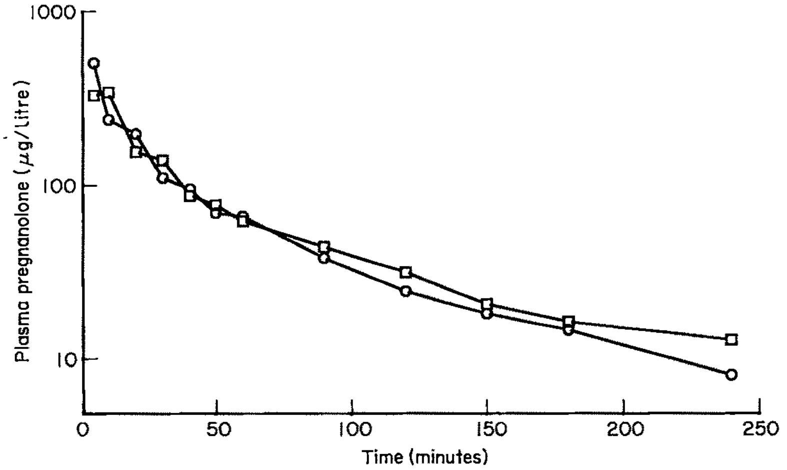

Fig. 1. Plasma concentration of pregnanolone in one subject after intravenous pregnanolone emulsion 0.5 mg/kg. ○—○, unconjugated pregnanolone; □—□, conjugated pregnanolone.

Table 2. Total serum concentrations of pregnanolone (μg/litre) in subjects 1–6 before and after various doses of pregnanolone emulsion (4 mg/ml).

Subject number	1	1	2	2	3	3	4	4	5	6
Administration	1	2	1	2	1	2	1	2	1	1
Dose (mg/kg)	0.05	0.5	0.15	0.4	0.4	0.3	0.6	0.5	0.6	0.6
Time (minutes)										
0	0	0	0	0	0	0	0	0	0	0
5	25	292	101	331	155	234	459	309	467	392
10	18	183	72	206	93	111	215	173	377	186
20		120		109		79	179	117	287	135
30		86		74		56	101	98	209	103
40		65		46		39	87	58	119	88
50		55		42		36	64	56	90	73
60		42		34		24	61	50	80	56
90		23		23		14	35	33	43	38
120		17		18		10	22	19	36	27
150		13		14		10	17	17	26	20
180		9		9		6	14	10	23	12
240		6		7		2	8	7	13	9

Table 3. Concentrations (μg/litre) of conjugated (total–unconjugated) pregnanolone in serum in subjects 1–6 before and after various doses of pregnanolone emulsion (4 mg/ml).

Subject number	1	1	2	2	3	3	4	4	5	6
Administration	1	2	1	2	1	2	1	2	1	1
Dose (mg/kg)	0.05	0.5	0.15	0.4	0.4	0.3	0.6	0.5	0.6	0.6
Time (minutes)										
0	0	0	0	0	0	0	0	0	0	0
5	9	247	155	375	206	125	300	375	242	325
10	6	171	117	194	166	75	309	238	193	172
20		76		222		32	143	151	117	217
30		55		74		20	128	84	101	92
40		53		64		28	80	74	62	59
50		49		48		8	70	46	69	50
60		35		43		10	57	34	62	42
90		28		33		9	41	29	39	29
120		27		29		8	29	25	52	25
150		13		24		9	19	10	47	21
180		11		15		11	15	13	16	17
240		9		10		6	12	9	10	15

Table 4. Pharmacokinetic variables of pregnanolone in subjects 1–6.

Subject number	1	2	3	4	4	5	6
Administration	2	2	2	1	2	1	1
Dose (mg/kg)	0.5	0.4	0.3	0.6	0.5	0.6	0.6
A (μg/litre)	203	342	168	293	167	540	229
α (l/hour)	2.49	4.60	3.94	2.77	2.81	3.27	3.18
B (μg/litre)	49	51	50	65	71	93	89
β (l/hour)	0.55	0.53	0.76	0.54	0.59	0.48	0.61
$t_{1\beta}$ (hours)	1.26	1.31	0.91	1.28	1.17	1.44	1.14
V_c (litre/kg)	1.98	1.02	1.38	1.68	2.10	0.95	1.89
V_d (litre/kg)	5.58	4.74	3.91	5.01	4.81	3.75	4.70
$AUC_{0-\infty}$ [(μg/hour)/litre]	163	160	101	222	176	333	209
Cl_{tot} [(litre/hour)/kg]	3.07	2.51	2.97	2.70	2.84	1.80	2.87

Table 5. Onset of anaesthesia in five subjects following intravenous doses of pregnanolone.

Subject number	3	4	4	5	6
Administration	1	1	2	1	1
Dose (mg/kg)	0.4	0.6	0.5	0.6	0.6
Injection time (seconds)	30	45	38	45	45
Time (seconds) to:					
Loss of eyelash reflex	75	75	75	75	90
Stop counting	20	—	39	33	35
Drop syringe	20	15	63	45	68

Table 6. Recovery data after intravenous doses of pregnanolone.

Subject number	3	4	4	5	6
Administration	1	1	2	1	1
Dose (mg/kg)	0.4	0.6	0.5	0.6	0.6
Time (minutes) to:					
Return of eyelash reflex	4.2	8.0	7.4	7.1	11.2
Spontaneous opening of eyes on command (waking time)	5.0	11.2	7.3	7.4	15.2
First verbal response	5.0	13.0	9.2	7.6	16.2
Full orientation in time and space	8.0	15.2	13.4	14.4	17.2
Subjectively unaffected by pregnanolone	50	40	45	40	35

Pharmacodynamics

The subjects who received PE at a dose of 0.6 mg/kg fell asleep, whereas this was the case with only one of two subjects who received doses of 0.4 mg/kg and 0.5 mg/kg, respectively. Time to loss of eyelash reflex varied from 75 to 90 seconds and time to stop counting from 20 to 39 seconds, followed shortly by dropping of the syringe (Table 5). The subjects opened their eyes on command 5.0 minutes after PE 0.4 mg/kg, 7.3 minutes after PE 0.5 mg/kg, and 7.4, 11.2 and 15.2 minutes after PE 0.6 mg/kg (Table 6). All subjects were fully orientated in time and space within a few minutes of regaining consciousness, but were still a little drowsy and a further period elapsed before they were clear-headed (Table 6).

Figures 2 and 3 show the changes in arterial blood pressure and pulse rate after induction doses of PE. These results differed from subject to subject without a uniform pattern. No ECG arrhythmia was observed.

A short period of hypoventilation was observed after induction of anaesthesia in five of six subjects as indicated by an increase of $P\text{aco}_2$ and a decrease of $P\text{ao}_2$ (Fig. 4). These alterations were transient and within the normal ranges of $P\text{aco}_2$ (4.3–6.0 kPa) and of $P\text{ao}_2$ (9.4–14.2 kPa). A significant increase in $P\text{ao}_2$ above normal limits was observed in one subject (dose 0.6 mg/kg). The $P\text{aco}_2$ remained elevated for more than 60 minutes (the last measurement of blood gas tensions was made 60 minutes after injection of PE), whereas $P\text{ao}_2$ returned to the baseline value within 60 minutes. The subject was totally unaffected by the increased $P\text{aco}_2$. pH and bicarbonate concentration were unchanged during the study period. Several recurrent apnoeic periods of about 10 seconds during 2 minutes were observed 20 minutes after injection of PE in subject number 4 (dose 0.5 mg/kg). At that time the subject had been fully awake, but he became drowsy if not stimulated. This lasted for about 5 minutes. This subject had earlier received PE 0.6 mg/kg without any periods of apnoea. No respiratory assistance or administration of oxygen was needed. Airway obstruction was not observed.

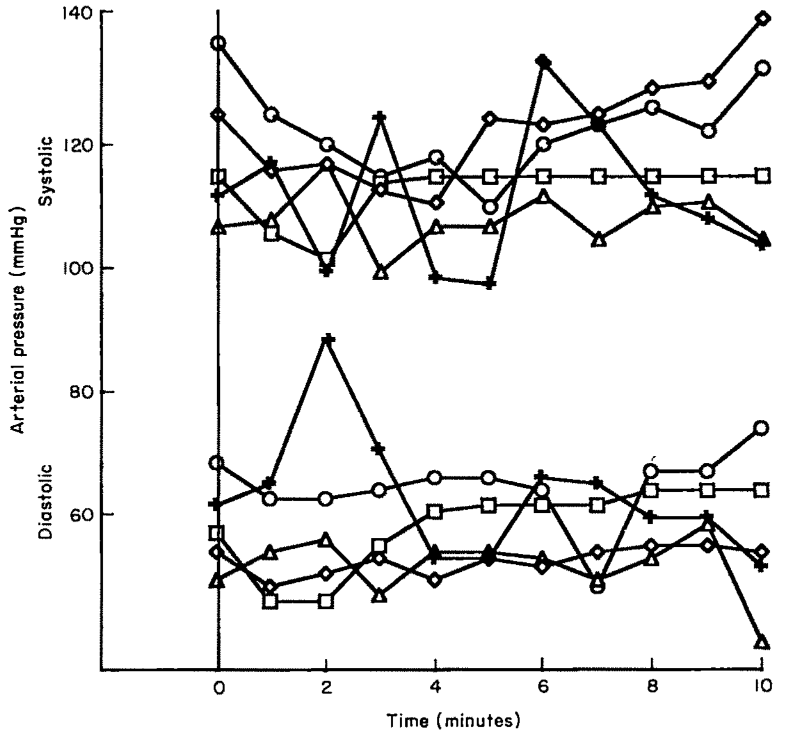

Fig. 2. Changes in systolic and diastolic arterial blood pressure after induction of anaesthesia with pregnanolone. Subject 3, 0.4 mg/kg (○—○); subject 4, 0.6 mg/kg (□—□); subject 4, 0.5 mg/kg (△—△); subject 5, 0.6 mg/kg (◇—◇); subject 6, 0.6 mg/kg (+—+).

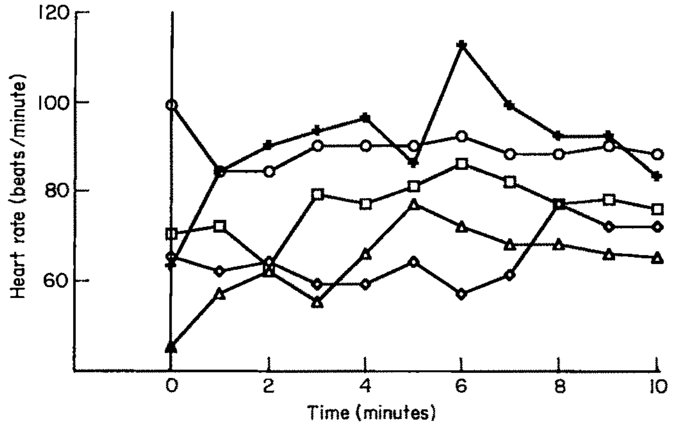

Fig. 3. Changes in heart rate after induction of anaesthesia with pregnanolone. Subject 3, 0.4 mg/kg (○—○); subject 4, 0.6 mg/kg (□—□); subject 4, 0.5 mg/kg (△—△); subject 5, 0.6 mg/kg (◇—◇); subject 6, 0.6 mg/kg (+—+).

The peripheral temperature increased by a few degrees in almost all of the subjects immediately after administration of PE, but in two of the subjects the increase in temperature was marked (up to 7.5°C 12 minutes after administration of PE). The core temperature was unchanged in all but one subject (subject number 3, dose 0.3 mg/kg) in whom core temperature increased by 1.3°C (from 37.6°C to 38.3°C) 10–11 hours after injection of PE. The temperature remained increased for about 2 hours. No leucocytosis was observed in relation to the temperature increase. In the other subjects the temperature followed the normal diurnal fluctuation[7] of 0.5–1.0°C.

Excitatory side effects were seen only in one subject (dose 0.6 mg/kg) about 2 minutes after administration of PE. The excitation was not pronounced and lasted for about 3 minutes. Another subject had slight involuntary muscle movements about 4 minutes after injection of PE, but no excitation was observed. Pain at the injection site and venous sequelae after administration of PE were not seen. No subject complained of nausea or other side effects

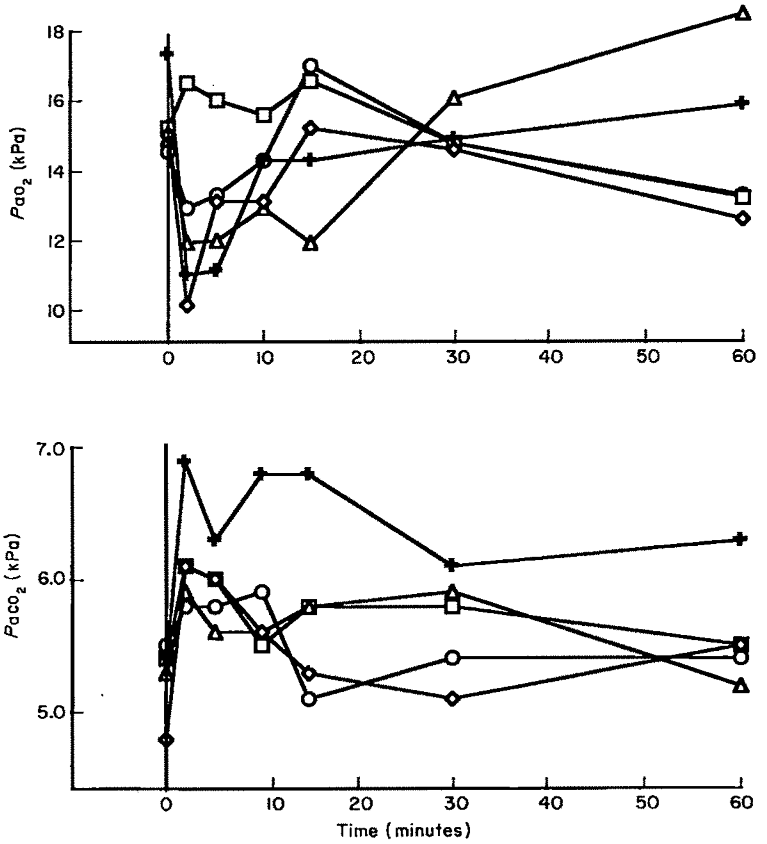

Fig. 4. Changes in Pa_{O_2} and Pa_{CO_2} after induction of anaesthesia with pregnanolone. Subject 3, 0.4 mg/kg (○—○); subject 4, 0.6 mg/kg (□—□); subject 4, 0.5 mg/kg (△—△); subject 5, 0.6 mg/kg (◇—◇); subject 6, 0.6 mg/kg (+—+).

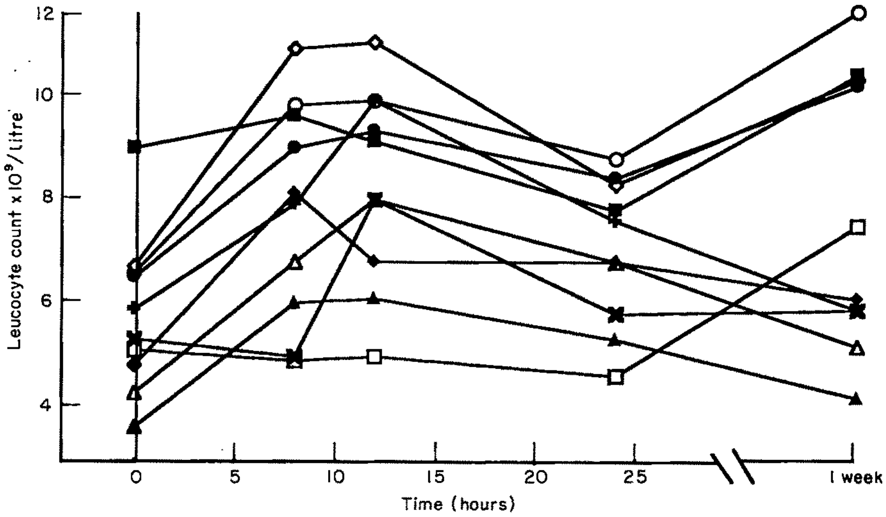

Fig. 5. Changes in leucocyte count after intravenous injection of pregnanolone. Subject 1, 0.05 mg/kg (○—○); subject 2, 0.15 mg/kg (□—□); subject 3, 0.4 mg/kg (△—△); subject 4, 0.6 mg/kg (◇—◇); subject 5, 0.6 mg/kg (+—+); subject 6, 0.6 mg/kg (×—×); subject 1, 0.5 mg/kg (●—●); subject 2, 0.4 mg/kg (■—■); subject 3, 0.3 mg/kg (▲—▲); subject 4, 0.5 mg/kg (◆—◆).

during the recovery period. All the subjects reported that they felt comfortable during and after injection of PE.

An increased white cell count occurred in nine of 10 subjects 8 hours after administration of PE (the first measurement after baseline value). In one case this exceeded 10% above the baseline value (Fig. 5); the white cell count was normal after 24 hours. Serum triglycerides increased as expected in all subjects after injection of PE. The increase exceeded 10% above the baseline value in four subjects (doses 0.5 and 0.6 mg/kg). Serum cholesterol was not affected. The concentration of free fatty acids increased in the same way as triglycerides. The other laboratory tests revealed no evidence that PE affected hepatic, renal or haematological parameters adversely.

Physical examination, biochemical and haematological tests revealed no abnormality one week after administration. Neither phlebitis nor thrombosis was detected at the injection site in any subject.

Discussion

The shapes of the concentration-time curves of unconjugated and conjugated pregnanolone were very similar, with equal disposition half lives. This implies very fast conjugation of the parent drug. It also implies that the disposition kinetics (distribution and elimination) of the parent drug are rate limiting for the kinetics of the metabolite. The fact that the curves are superimposed with equal AUC suggests either that most of the parent drug forms the conjugate and the two have similar clearance or, more likely, that the clearance of the conjugate and fraction of drug forming the conjugate are both smaller.

Elimination in the liver of a highly cleared drug (extraction ratio approaching 1) is limited by the blood flow in this organ (1.5 (litres/hour)/kg). Thus, pregnanolone (total body clearance between 1.80 and 3.07 (litre/hour)/kg) must also be cleared by other tissues.[8,9]

Our results show that about 10% of pregnanolone is excreted as conjugates in the urine and very little (less than 0.1%) as unchanged drug in 24 hours. The total body clearance of the drug is large and it can be calculated that less than 8% (between 3 and 8%) of the unchanged drug remains in the body after 4 hours. Data obtained on excretion of pregnanolone in pregnant women[10] and in rats given radioactive pregnanolone[8] suggest that faecal excretion is an important route of elimination of both conjugated and unconjugated pregnanolone.

The pharmacokinetic profile of pregnanolone suggests that there should be a lower cumulative effect than any of the barbiturate intravenous agents; this should enable easily controlled and flexible intravenous sedative regimens to be implemented as well as ensuring rapid recovery without 'hangover'. However, major changes in liver blood flow and, perhaps less importantly, liver metabolism, may have marked effects on the disposition of the drug in the body and therefore on its clinical effects, although organs other than the liver possibly participate in the metabolism of pregnanolone.[8,9]

Plasma concentrations of alphaxalone after a single injection of 0.7 mg/kg (induction dose of Althesin)[11] are almost identical to the concentrations of pregnanolone found in this study after an induction dose of PE 0.6 mg/kg. Total body clearance of PE is greater (1.5–2.5 times) than the clearance of Althesin (1.2 (litres/hour)/kg) and the volume of distribution (V_d) would appear to be 2 to 4 times that of Althesin (1.37 litre/kg).[11] The half lives of PE were much larger than those reported for Althesin ($t_{\frac{1}{2}\alpha} = 1.6$ minutes; $t_{\frac{1}{2}\beta} = 34$ minutes),[11] probably reflecting the larger volume of distribution.

Experimental results from animal studies have indicated that the pharmacodynamic properties of PE are similar to those of Althesin.[4-6] The present study confirms the similarity in pharmacodynamic properties: induction of anaesthesia with PE was rapid and with similar speed of onset to Althesin,[12,13] sleep could be produced in one arm–brain circulation time, and recovery time and cardiorespiratory effects were similar to those associated with Althesin.[13-16]

The body temperature was elevated to 38.3°C 11 hours after injection of PE in one subject (dose 0.3 mg/kg) without simultaneous leucocytosis, but the temperature increase was transient and could be ascribed to reasons other than a reaction to PE. However, several studies have described the pyrogenic action of steroids in man; pregnanolone (dissolved in small amounts of 95% ethyl alcohol) has been described as particularly pyrogenic.[17-22] The steroid pyrogens are effective in producing fever characterised by a peak temperature elevation, which may reach 4°C or more above normal, 9 to 12 hours after injection. Steroid pyrogen fever is associated with a significant leucocytosis; the leucocyte count may reach levels 2 to 4 times normal, and usually regresses as temperature subsides. Repeated injection of steroid pyrogens does not result in development of tolerance. Studies with isotopically labelled etiocholanolone indicate that the steroid pyrogen is rapidly conjugated, and cleared from the blood largely via urine excretion; neither peak blood nor cerebrospinal fluid concentrations of steroid coincide with the period of maximum temperature elevation. A significant portion of injected steroid pyrogen has already been excreted by the time the temperature elevation occurs and that portion of administered steroid found in plasma when thermogenesis begins is nearly all in the form of inert physiological conjugates. Thus it remains uncertain whether free steroid acts directly on thermoregulatory centres, whether a derivative of injected steroid is active proximally, whether a prolonged stimulus of appropriate central nervous system centres by free steroid (or derivative) is essential to thermogenesis, or whether some specific product of steroid–tissue interaction at the site of local injection is the critical event in steroid-induced fever.[22]

A maximum dose of 25 mg pregnanolone has been used either intramuscularly or intravenously[18,19] in studies on pyrogenic steroids in man. Both smaller and larger doses of pregnanolone were injected in the present study. Large doses of steroids may elicit pharmacological effects which counteract those produced by small doses in a manner comparable to the effects on the body temperature which may be induced by small and large doses of bacterial pyrogen.[23] Rapid injection of pregnanolone required for anaesthetic purposes may be ineffective in provoking fever, as suggested by Kappas *et al.*[18] in studies with the highly potent steroid pyrogen 3α-hydroxy-pregnane-11, 20-dione. It is also possible that the effect of steroid pyrogens on cerebral thermoregulatory centres is blocked during anaesthesia.

The peripheral temperature increased by a few degrees in almost all of the subjects immediately after administration of PE, but in two of them the increase in temperature was marked (up to 7.5°C). These subjects were stressed by the situation and were cold peripherally after insertion of the arterial line.

The only side effects seen after injection of PE were slight respiratory depression of short duration, excitation in one subject (the subject was nervous before injection of PE and there had been problems with insertion of the radial artery catheter) and involuntary muscle movement in another subject. Involuntary muscle movements were seen frequently with Althesin, especially when higher doses were used for induction of anaesthesia[24] and premedication with opioids tended to decrease the frequency of abnormal muscle movements. No cases of venous sequelae were seen. The incidence of thrombophlebitis after Althesin was similar to that seen after dilute solutions of barbiturates.[25] An intense phlebitic and periphlebitic inflammation was described[20] after prolonged intravenous administration of pregnanolone dissolved in small amounts of 95% ethyl alcohol.

It is impossible to draw any clear conclusions of the clinical efficacy and tolerance from this limited normal subject trial, but PE appears to be worthy of further trial in man.

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Induction agents for day-case anaesthesia

A double-blind comparison of propofol and midazolam antagonised by flumazenil

A. C. NORTON AND C. R. DUNDAS

Summary

Early postoperative recovery was studied using sedation scoring, measurement of flicker fusion frequency and completion of Trieger test figures in 60 male patients who presented for vasectomy under general anaesthesia as day patients. Anaesthesia was induced in groups 1 and 2 (20 patients each) with mean (SD) doses of 0.16 (0.04) mg/kg or 0.16 (0.03) mg/kg midazolam respectively; group 2 received flumazenil 0.55 (0.19) mg after completion of surgery. The remaining 20 patients (group 3) received propofol 1.50 (0.24) mg/kg. Anaesthesia was maintained with isoflurane vaporized in 33% oxygen and nitrous oxide in all patients. Flumazenil tended to improve tests of recovery after midazolam anaesthesia, but early recovery after propofol anaesthesia was associated with better psychomotor test results and less impairment of mental state as judged by sedation and amnesia scoring.

Key words

Anaesthetics, intravenous; propofol, midazolam.
Benzodiazepine antagonists; flumazenil.

Anaesthesia for day-stay surgery requires that recovery should not be unduly prolonged and that there should be minimal residual effects so that patients may be discharged in a 'street-fit' condition. Many agents have been investigated for induction of day-case anaesthesia, but none has received universal support,[1] although the emulsion formulation of propofol has proved popular;[2,3] the advantage of a generally rapid recovery often outweighs the disadvantages of pain on injection and cardiovascular and respiratory depression.

Flumazenil, a competitive antagonist at the benzodiazepine receptor complex, is reported to be effective in reversing general anaesthesia induced by flunitrazepam[4] or midazolam.[5,6] The present study was designed to assess the quality of postoperative recovery after anaesthesia induced by midazolam and followed by administration of flumazenil or placebo, and to compare these techniques with the quality of recovery after induction of anaesthesia with propofol.

Young male patients who presented for one operation (vasectomy) were studied in order to standardise as many variables as possible. The accurate assessment of postoperative recovery requires tests that have an appropriate degree of discrimination and sensitivity to determine whether 'recovery' has taken place. Drummond[7] considers that 'those that most nearly approach the criterion of a simple, reproducible, quantitative, sensitive, and discriminating test seem to be short-term memory tests and the flicker fusion test', although Grove-White and Kelman[8] consider that the flicker fusion test may be too sensitive for the assessment of recovery from anaesthesia. Trieger test figures[11] were also included in the tests administered to provide further estimation of sensorimotor performance.

Methods

The study was conducted under a protocol for a randomised double-blind controlled trial approved by the local Ethics Committee. Male patients presenting for vasectomy under general anaesthesia were seen after admission to the Day Ward by the observer (A.C.N.) who assessed suitability to enter the trial, obtained informed consent, performed pre-operative tests and weighed the patient. Exclusions from the trial included: pre-existing benzodiazepine or other psychotropic therapy; significant psychiatric disorder; failure to obtain informed consent; surgical difficulties that prolonged surgery for more than 30 minutes; unanticipated anaesthetic difficulties; or patients who were not graded as ASA categories 1 or 2.

Sixty-four patients were studied, four of whom were later excluded from further analysis due to exclusions 4 and 5 above. The unpremedicated patients were allocated on

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arrival at the operating theatre to one of three groups according to an age-stratified randomisation code supplied by the Department of Statistics, University of Aberdeen. All the anaesthetics were given by one anaesthetist (C.R.D.). The anaesthetist subjectively rated the ease and safety with which anaesthesia was induced by application of a numerical score—0, no difficulty encountered; 1, minor and/or easily remediable complications; 2, moderate complications which could be regarded as potentially dangerous; 4, severe adverse events.

Anaesthetic techniques studied

Group 1. Anaesthesia was induced by infusion of midazolam 0.075 (mg/kg)/minute by a volumetric infusion pump (see below) and subsequently maintained with isoflurane vaporized in 33% oxygen and nitrous oxide. Surgery was then performed. Ten millilitres of a placebo solution were injected intravenously 10 minutes after the discontinuation of inhalational anaesthesia.

Group 2. Anaesthesia was induced and maintained in an identical fashion to group 1. Flumazenil was titrated intravenously against clinical response up to a maximum dose of 1 mg (10 ml of solution) 10 minutes after the discontinuation of inhalational anaesthesia.

Group 3. Anaesthesia was induced by infusion of propofol 0.8 (mg/kg)/minute and subsequently maintained with isoflurane vaporized in 33% oxygen and nitrous oxide. Ten millilitres of placebo solution were administered intravenously 10 minutes after the discontinuation of inhalational anaesthesia.

Induction of anaesthesia by infusion of midazolam or propofol

A 20-gauge intravenous cannula was sited in a vein of the antecubital fossa of the nondominant arm and connected to a volumetric infusion pump (IMED 960) by a length of manometer tubing. The patient was then asked to listen to an auditory signal generator which emits a 0.1 second pulse of frequency 1000 Hz once each second. Using the dominant hand, the patient was asked to respond to the pulsed sound with an impedance plate-activated signal generator emitting 2000 Hz. Infusion of the induction agent and a timer were started without the patient's knowledge when a regular rhythm of response was established. Infusion continued until the patient ceased to respond to the signal generator. The infusion time was thus related directly to the induction dose in mg/kg.

Postoperative care and investigations

Immediate postoperative recovery took place in the recovery ward. The patients were discharged to the Day Ward at the discretion of recovery ward nursing staff who assessed sedation levels according to a four-point scale at the time of discharge from the recovery area.

All other observations were carried out in the Day Ward by an observer (A.C.N.) who was unaware of the treatment group to which the patient was allocated. Recovery from anaesthesia was assessed by means of sedation, orientation, comprehension and amnesia (SOCA) scoring[5,6,9] by the observer, determination of critical flicker fusion frequency (CFFF)[7,10] and completion of a Trieger test figure[11] at 0.5, 1, 2 and 4 hours after the end of anaesthesia. Sedation scoring was carried out by subjective rating by the observer using the following scales. Sedation: 4, awake and alert or tense; 3, awake and not alert or tense; 2, drowsy; 1, sleepy or asleep but rousable; 0, asleep and not rousable (in calculation of pooled SOCA scores a maximum score of 3 is given by pooling of scores of 3 and 4). Orientation was assessed by means of response to standardised questions of temporospatial orientation: 2, full orientation; 1, partial disorientation; 0, total disorientation. Comprehension/collaboration were assessed by response to simple direct commands: 2, execution of order; 1, execution of order only by imitation; 0, no execution of order. Amnesia was assessed by recall of three picture cards; 3, no amnesia; 2, slight amnesia; 1, moderate amnesia; 0, severe amnesia. Scores in each category are pooled to give the SOCA score (maximum score = 10).

CFFF was measured using the subject's dominant eye to observe a flickering light-emitting diode (LED) driven by a variable frequency square wave oscillator. The LED was sited at the end of an apertured nonreflective 0.7 m length of black plastic tubing, such that the angle subtended on the eye was less than 1 degree. After conditioning, three determinations were made at each time point; increasing frequency of oscillation was used on all occasions.

Patients were asked before discharge (a minimum of 4 hours after surgery) to complete a brief questionnaire and were given a set of written instructions about the post-operative period and arrangements for follow-up.

Statistics

Tests employed included one-way analysis of variance and calculation of F ratio, Kruskal–Wallis one-way nonparametric analysis of variance, and the Chi-square test.

Results

The groups of patients were well matched as regards age and weight (Table 1). Data regarding induction dosage with the infusion technique employed are shown in Table 2. The mean doses of midazolam administered to the placebo and flumazenil groups were very similar; the mean difference required to achieve the induction end point was 0.001 mg/kg. The induction time for propofol was significantly shorter, and we estimate that an infusion rate of 0.7 (mg/kg)/minute of propofol would produce a similar mean induction time. The relative potencies of midazolam and propofol from these data are 9.25 to 1. The subjective rating of the ease and safety with which anaesthesia was induced indicated no difficulties in the propofol group, but six cases of minor complications and one case of moderate

Table 1. Ages and weights of the patients in each group. Data are presented as mean (SD) and 95% confidence intervals (CI).

	Midazolam	Midazolam + flumazenil	Propofol
Age (years)	34.3 (4.3)	33.9 (5.4)	33.3 (4.7)
CI	32.3 – 36.3	31.4 – 36.4	31.1 – 35.5
Weight (kg)	79.9 (13.9)	76.6 (10.5)	79.6 (7.4)
CI	73.4 – 86.4	71.7 – 81.5	76.1 – 83.1

Table 2. Data from induction of anaesthesia. Data are presented as mean (SD).

	Midazolam	Midazolam + flumazenil	Propofol
Infusion time (minutes)	2.15 (0.58)	2.16 (0.39)	1.88 (0.31)
Induction dose (mg)	12.63 (2.87)	12.40 (2.71)	119.24 (19.00)
Induction dose (mg/kg body weight)	0.161 (0.04)	0.162 (0.03)	1.50 (0.24)

Table 3. Sedation scoring by recovery nurses at time of discharge from recovery room.

Sedation score	Midazolam	Midazolam + flumazenil	Propofol
3/4 (Awake)	9	20	20
2 (Drowsy)	8	0	0
1 (Sleepy/rousable)	3	0	0
0 (Sleepy/unrousable)	0	0	0

$p < 0.001$.

complications were reported in the 40 patients anaesthetised with midazolam. The mean (SD) dose of flumazenil administered to patients in group 2 was 0.55 (0.19) mg.

Table 3 shows the sedation scores recorded by recovery room nurses at the time of handing over the patient to the trial observer. Large numbers of the midazolam/placebo patients remained sleepy or drowsy, whereas all patients who received flumazenil or propofol were awake at the time of transfer to the day ward. Eight patients in group 1 were unable to complete the psychomotor tests at 30 minutes after surgery due to residual sedation.

Table 4 shows the distribution of SOCA scores at the times of testing. Small decreases in SOCA score were generally due to degrees of amnesia which were more severe in the midazolam groups. Treatment with flumazenil only partially improved the amnesia observed after midazolam and there was some evidence of resedation in group 2 at 1–2 hours after surgery. Significantly higher SOCA scores were observed after propofol, but mild degrees of amnesia in the card retention test were present in two patients in group 3 at 4 hours.

The results in psychomotor tests employed are shown in Figures 1–4. There was a significant difference in control CFFF in group 1 compared with groups 2 and 3 ($p < 0.01$, one-way ANOVA). CFFF data are presented as mean change from control value. The smallest reduction in CFFF occurred in the propofol group. Flumazenil tended to ameliorate the decrement in performance compared to placebo at 0.5, 1 and 2 hours after surgery, but performance remained inferior to that after propofol. There was no significant difference between any of the groups in testing by CFFF or Trieger tests 4 hours after surgery. Performance on the Trieger test figure after midazolam and flumazenil tended to be intermediate between midazolam/placebo and propofol until 4 hours after anaesthesia.

Table 4. Sedation, orientation, comprehension, amnesia (SOCA) scores.

Time (hours)	Groups	Score bands 10	7–9	4–6	<4	p
0.5	1	3	7	2	8	
	2	15	5	0	0	<0.001
	3	16	4	0	0	
1	1	3	14	3	0	
	2	6	13	1	0	<0.001
	3	16	4	0	0	
2	1	3	13	4	0	
	2	7	12	1	0	0.001
	3	15	5	0	0	
4	1	10	10	0	0	
	2	12	8	0	0	0.02
	3	18	2	0	0	

There were no significant differences in minor postoperative morbidity (Table 5) among the three groups, although more patients in group 3 admitted to postoperative headache. No significant adverse effects that could have been attributed to flumazenil were observed. A greater proportion of patients who received propofol rated themselves as fit to drive or return to work after completion of tests at 4 hours (Table 6). All the patients received written instructions at discharge and were categorically instructed not to drive or operate machinery until the next day.

Discussion

Few intravenous induction agents have withstood the test of time, and many agents have been promoted as suitable

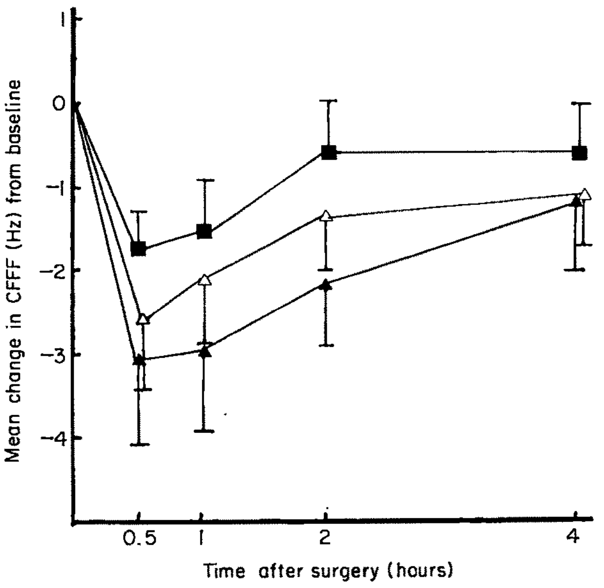

Fig. 1. Changes in critical flicker fusion frequency (CFFF) compared to mean baseline values. Values plotted are mean (95% confidence intervals). Probability of intertreatment group difference < 0.05 at 0.5 hours, < 0.01 at 1 and 2 hours, not significant at 4 hours. ▲, midazolam; △, midazolam and flumazenil; ■, propofol.

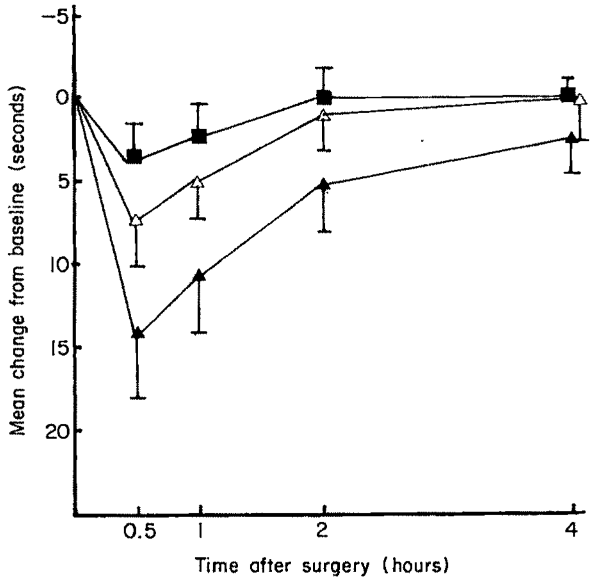

Fig. 2. Times taken to complete Trieger test figure compared to mean baseline time. Values plotted are mean (95% confidence intervals). Probability of intertreatment group difference < 0.01 at 0.5 and 1 hours, not significant at 2 and 4 hours. ▲, midazolam; △, midazolam and flumazenil; ■, propofol.

for use in day cases. There has been a conflict of views regarding the suitability of midazolam as an intravenous induction agent. Some authors maintain that midazolam is an unreliable induction agent[12,13] while others[14-16] have found it to have acceptable induction characteristics and a reasonably close relationship between ED_{50} and ED_{95}. It is suggested that midazolam is as suitable as thiopentone for day-case surgery;[17] the authors of this report concluded that although early recovery was slower after midazolam than thiopentone, the incidence of undesirable effects such as nausea and fatigue was less in patients who received midazolam. Propofol has proved very popular as an induction agent in day-patient surgery since its introduction in an emulsion formulation.[2,18-21]

The introduction of flumazenil raised the possibility that recovery after anaesthesia induced with midazolam could be significantly improved in terms of residual sedation and drowsiness, thus overcoming one of its main disadvantages. Previous studies[6,22] of the use of flumazenil after general anaesthesia with midazolam have evaluated differences in recovery between patients treated with placebo or flumazenil on the basis of sedation scoring. However, Raeder *et al.*[23] reported greater impairment of four-choice reaction time and p-deletion score after total intravenous anaesthesia with midazolam followed by either placebo or flumazenil than after a thiopentone/alfentanil/nitrous oxide anaesthetic, and it was noted that flumazenil did not antagonise fully the early depression of performance in these psychomotor tests. However, this study reported effective and sustained wakefulness after reversal of midazolam 0.3 mg/kg with flumazenil.

We therefore designed this study to evaluate postoperative recovery by both sedation scoring and psychomotor testing, ensuring that the induction doses of propofol and midazolam could be regarded as functionally comparable, since the patients were all induced to the same clinical endpoint of failing to respond to a regular pulsed sound stimulus. The induction doses that were used with this technique are relatively small considering the nature of the patients studied and when compared to previously published work.[12,13] Halliday *et al.*[24] reported that 40% of patients aged under 50 years were still awake 3 minutes after midazolam 0.3 mg/kg but Reves *et al.*[16] found that the ED_{50} for an induction dose of midazolam is 0.13 mg/kg. Studies of propofol as an induction agent for day patient anaesthesia commonly employ a dose of 2.5 or 3 mg/kg propofol.[2,3,20,25]

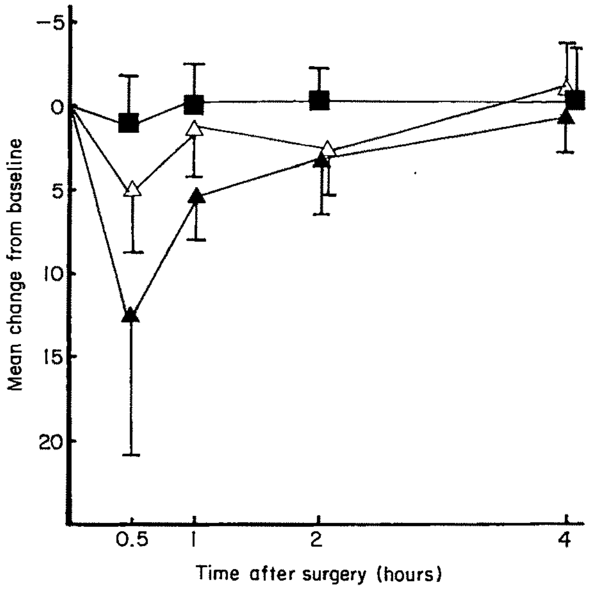

Fig. 3. Mean changes in number of dots missed in completion of Trieger test figures compared to baseline mean. Values plotted are mean (95% confidence intervals). Probability of intertreatment group difference < 0.001 at 0.5 and 1 hours, < 0.01 at 2 hours, not significant at 4 hours. ▲, midazolam; △, midazolam and flumazenil; ■, propofol.

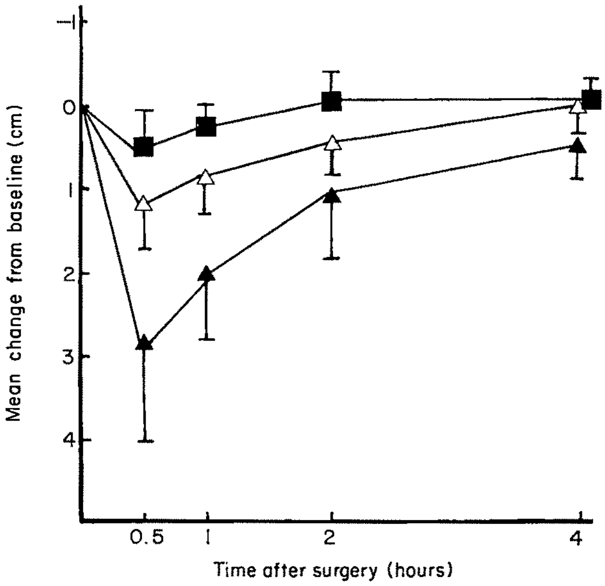

Fig. 4. Mean changes in summed magnitude of error (cm) in completion of Trieger test figures compared to baseline mean. Values plotted are mean (95% confidence intervals). Probability of intertreatment group difference < 0.001 at 0.5, 1 and 2 hours, not significant at 4 hours. ▲, midazolam; △, midazolam and flumazenil; ■, propofol.

Table 5. Postoperative adverse effects.

	Headache			Nausea or vomiting		
Severity	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3
None	18	16	14	19	18	18
Mild	2	4	5	1	2	2
Significant	0	0	1	0	0	0

Table 6. Self-assessment at time of discharge from hospital.

	Group 1	Group 2	Group 3
Do you feel back to your normal self?			
Yes	13	15	16
A little below par	7	5	3
Substantially below par	0	0	1
If instructed to do so, how do you think you would perform in driving a car through the city?			
Normally	4	8	13
A little inefficiently	7	4	5
A little dangerously	7	8	1
Very dangerously	1	0	1
If instructed to now do your normal day's work, how would you perform?			
Normally	4	7	9
A little inefficiently	14	11	6
Very inefficiently	2	2	5

The results presented in this study have demonstrated that flumazenil tended to improve recovery and indices of psychomotor performance after midazolam anaesthesia, but that propofol anaesthesia was associated with better psychomotor test results and was also associated with less impairment of memory. The induction dose of midazolam administered in this study is relatively conservative, and these findings suggest the possibility of synergism between midazolam and isoflurane, the effect of which is not reversed by flumazenil.

The magnitude of early impairment after midazolam and the magnitude of improvement by flumazenil on early postoperative testing tends to be underestimated, since eight patients who received midazolam and placebo were unable to complete psychomotor testing at 30 minutes. Flumazenil did not reverse completely the continuing postoperative amnesia induced by midazolam, and the presence of mild amnesia at the time of discharge in two patients who received propofol, emphasises the need for written discharge instructions to be given to all day patients who receive general anaesthesia. We conclude that in the absence of specific contraindications, propofol is more suitable for use as an induction agent for day patients than midazolam, whether flumazenil is used or not.

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Anaesthesia, 1990, Volume 45, pages 204–209

Intravenous propofol anaesthesia using a computerised infusion system

M. WHITE AND G. N. C. KENNY

Summary

Propofol offers many advantages as a total intravenous anaesthetic agent compared with other agents. However, considerable experience is necessary in order to give an uncomplicated anaesthetic. A mathematical model which describes the pharmacokinetic behaviour of the drug was incorporated into a computerised delivery system which enables the anaesthetist to achieve and maintain a target blood concentration of propofol and to manipulate this at will. The system was used to provide general anaesthesia for 33 healthy patients who underwent general surgery. A strong statistical relationship was found between measured blood propofol concentrations and the corresponding computer predictions ($y = -0.50 + 1.36x$). *No significant differences in this relationship were found between patients who breathed spontaneously* ($y = -0.71x + 1.43x$) *and those who received intermittent positive pressure ventilation* ($y = -0.33 + 1.32x$).

Key words

Anaesthetics, intravenous; propofol.
Equipment; computers, infusion pumps.

There has been interest for many years in the maintenance of anaesthesia with intravenous drugs as an alternative to inhalational agents.[1] The withdrawal of propanidid and Althesin, and the problems related to suppression of adrenocortical function with etomidate, have led to the emergence of propofol as the most suitable intravenous anaesthetic for this purpose. Propofol offers many advantages as a total intravenous anaesthetic in terms of its pharmacokinetic profile,[2] but anaesthetists are not familiar generally with the use of intravenous agents to maintain anaesthesia compared with standard volatile anaesthetics delivered via calibrated vaporizers.

Various suggestions have been proposed for suitable infusion rates of propofol to maintain satisfactory anaesthesia.[3,4] Roberts *et al.*[5] have proposed a manual infusion scheme designed to achieve a constant blood level throughout the duration of surgery and the success of this regimen has been confirmed during computer-controlled infusion of propofol,[6] intended also to maintain a constant blood concentration during anaesthesia. However, such a scheme has the principal disadvantage of inability to vary the blood propofol concentration in response to changing surgical and anaesthetic requirements. Volatile agents may then have to be introduced to maintain adequate anaesthesia.[6]

Consequently, we believe that there is a need for a system which enables the anaesthetist to alter the depth of anaesthesia in as simple a manner as that used for volatile agents. We have constructed a computer-controlled device for the infusion of propofol which fulfils this requirement. The performance of the system has been evaluated by comparing the predicted blood concentrations of propofol selected by the anaesthetist to produce a satisfactory level of anaesthesia with the values measured from blood samples.

Methods

Computer system

The pharmacokinetic variables which influence the distribution and elimination of propofol[2] have been incorporated into a computerised delivery system which is designed to allow the anaesthetist at any time to achieve and maintain the desired blood concentration of propofol.

The predicted blood concentration is achieved by a preselected rapid zero-order infusion and thereafter is controlled automatically to maintain the concentration at the desired level. Our system incorporates a three-compartment mathematical model of the pharmacokinetics of

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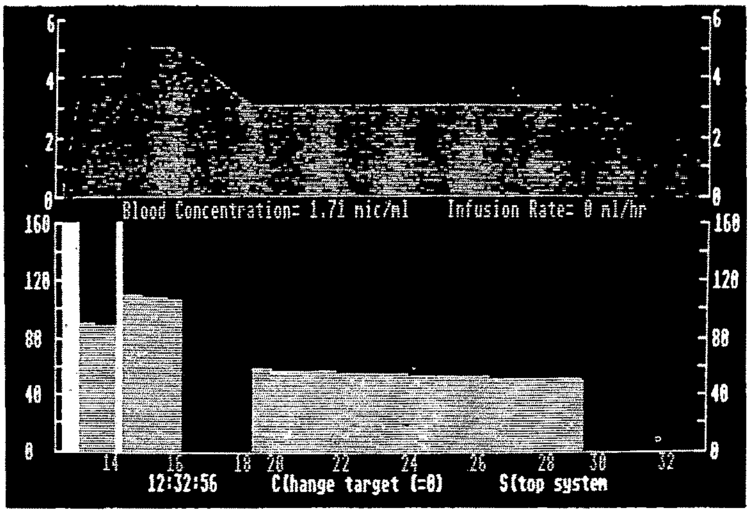

Blood Concentration= 1.71 mic/ml Infusion Rate= 0 ml/hr

12:32:56 C(hange target (=0) S(top system

Fig. 1. Screen display of predicted blood propofol concentration and infusion rate.

propofol which is capable at all times of calculating the distribution of the drug between the three compartments and allows the predicted concentration to be manipulated in any direction at any point in time.

The system is based on an Atari 1040ST microcomputer which is connected to an Imed 929 computer-controlled infusion pump via an RS-232 interface. The control program is written in GFA BASIC and compiled to produce an auto-boot system.

The program consists of: a three-compartment mathematical model which describes the pharmacokinetics of propofol; routines to control the infusion pump and monitor alarm messages; graphical display of the predicted blood concentration of propofol and the infusion rate required to achieve the predicted target level; input routines to allow the anaesthetist to enter patient weight, and desired target concentration; a data recording facility to store the target concentration selected, the rate of propofol infusion and the distribution of the drug within the three compartments of the model (these data are stored after every alteration of the blood concentration and every minute while in the steady maintenance phase of anaesthesia).

The target concentration is entered into the computer before induction of anaesthesia. Induction is achieved by a rapid zero-order infusion at a rate of 1200, 600 or 300 ml/hour as selected by the anaesthetist. The program calculates the theoretical blood concentration achieved twice per second and when the predicted concentration has been attained, the zero-order infusion is discontinued automatically. The system then switches over to an alternative mode of infusion which is designed to maintain the blood propofol concentration at the desired level by compensating continually for elimination and redistribution of the drug to the peripheral compartments. The anaesthetist has the option at all times of interrupting this mode of operation and selecting either a higher or lower blood concentration.

Table 1. Demographic data. Values are expressed as mean (SD) and range.

	All patients $n=33$	IPPV $n=13$	Spontaneous $n=20$
Age, years	45.2 (14.5) 20–72	48.4 (13.8) 20–69	43.1 (14.5) 22–72
Weight, kg	68.8 (11.4) 50–95	64.5 (10.0) 52–81	68.3 (11.9) 50–95
Male/female	12/21	7/6	5/15

A higher propofol concentration is achieved by reverting to a rapid zero-order infusion and calculating the concentration until the new predicted value is reached. A lower concentration is obtained by discontinuing the propofol infusion until the mathematical model predicts that the new target has been achieved by the processes of elimination and redistribution. In either case, the system switches automatically back to maintain the concentration at the selected level when the new predicted blood concentration has been achieved.

Thus the system has the capability of manipulating the blood concentration of propofol rapidly in accordance with varying anaesthetic and surgical requirements. The system is used in a similar manner to that in which a vaporizer is employed to achieve and maintain a given anaesthetic level. Blood propofol concentrations are manipulated in much the same way as a vaporizer manipulates alveolar, and hence blood, concentrations of a volatile agent. The predicted blood concentration is displayed on the colour monitor screen as a plot of concentration against time together with the relevant numerical values (Fig. 1). The lower part of the screen displays the infusion rates necessary to achieve the required concentration.

Table 2. Equations for the correlation of measured (y) with predicted (x) blood concentrations of propofol.

All patients $n=33$	IPPV $n=13$	Spontaneous ventilation $n=20$
$y=-0.50+1.36x$ $r=0.82$	$y=-0.33+1.32x$ $r=0.84$	$y=-0.71+1.43x$ $r=0.81$

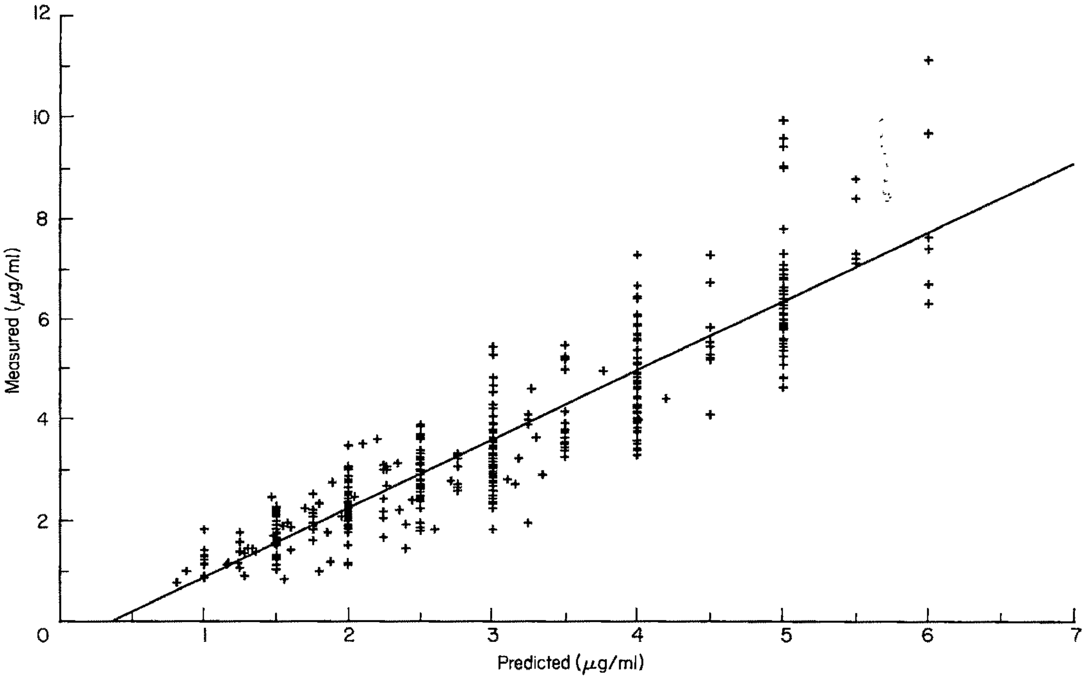

Fig. 2. Comparison of predicted and measured blood propofol concentrations for all 33 patients ($n = 410$).

Patients

Thirty-three patients scheduled to undergo general surgery were anaesthetised using the computer-controlled infusion system. The patients received temazepam 20–40 mg as premedication. A bolus dose of alfentanil 0.5 mg was given immediately before induction of anaesthesia, and the selected target blood concentration to induce anaesthesia was entered into the computer. The target was altered thereafter to control blood concentrations appropriate to the surgical stimulus that prevailed at the time.

Anaesthesia was supplemented with nitrous oxide 66% in oxygen and patients received a continuous infusion of alfentanil 0.25 μg/kg/minute. Patients who were to receive intermittent positive pressure ventilation (IPPV) were given atracurium 0.5 mg/kg to permit intubation of the trachea, followed by a continuous infusion of 0.25 mg/kg/hour. Twenty of the 33 patients breathed spontaneously, and 13 received IPPV. Propofol concentrations of 410 blood samples collected during anaesthesia were analysed by gas liquid chromatography and compared with the predicted values.

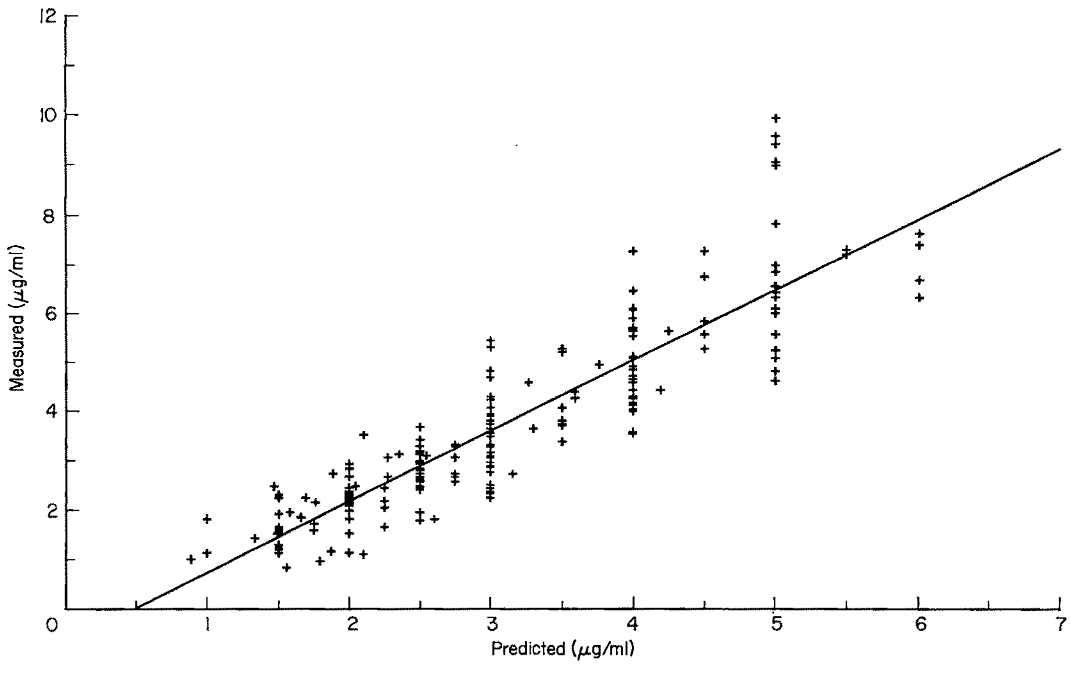

Fig. 3. Comparison of predicted and measured blood propofol concentrations for 20 patients who breathed spontaneously ($n = 206$).

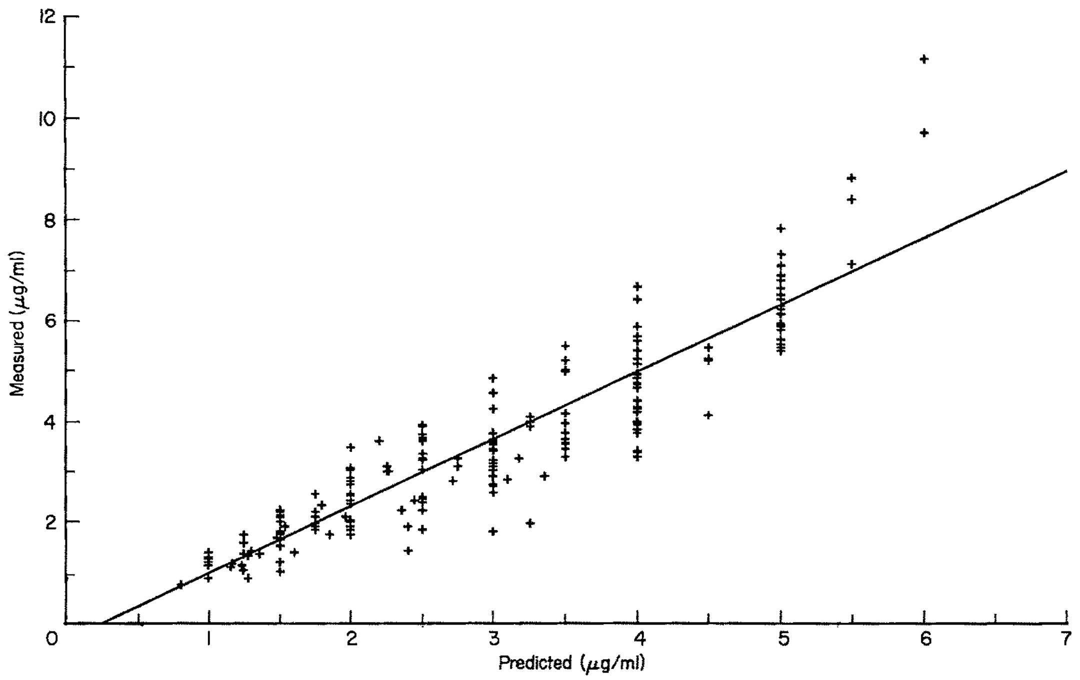

Fig. 4. Comparison of predicted and measured blood propofol concentrations for 13 patients who received IPPV ($n = 204$).

Results

The demographic data are shown in Table 1. There were no significant differences in age, weight or sex between the groups of patients who received IPPV and those who breathed spontaneously.

The blood concentrations predicted by the computer system correlated well with the measured values over the range of 1–6 μg/ml (Table 2; Fig. 2). There were no differences in the relationship of predicted to measured propofol concentrations between patients who breathed spontaneously and those who received IPPV (Table 2; Figs 3 and 4). Target predicted blood concentrations in the range 3–6 μg/ml were required to induce anaesthesia. Maintenance of satisfactory anaesthesia required predicted blood concentrations of 2–6 μg/ml, depending on the degree of patient fitness and extent of surgical stimulation, but no supplementary volatile agents were required.

Figure 5 illustrates the time course of predicted and measured propofol concentrations required to induce and maintain anaesthesia in a spontaneously breathing, fit female patient, age 34 years, weight 59 kg, who underwent ligation of varicose veins. A predicted concentration of 6 μg/ml was required to induce anaesthesia and this value had to be maintained to provide satisfactory operating conditions. The maximum infusion rate necessary to maintain anaesthesia was 133 ml/hour. Figure 6 illustrates the predicted and measured blood propofol concentrations required for a female patient aged 68 years, weight 65 kg, who received IPPV and underwent cholecystectomy. Anaesthesia was induced with a predicted concentration of 3 μg/ml and subsequently maintained within the range of 2–3 μg/ml.

Discussion

Schüttler and his colleagues[7] demonstrated that computer-controlled infusions of alfentanil and propofol could be used to produce satisfactory intravenous anaesthesia. However, their anaesthetic technique was different from that used in our study. They investigated only patients who were given neuromuscular blocking agents and who received IPPV. The target blood concentration of propofol was maintained constant at between 2.5 and 3.0 μg/ml during surgery and until the last suture for skin closure was inserted, while the infusion of alfentanil was altered in response to varying surgical stimulation. Many of their patients had measured alfentanil concentrations greater than 200 ng/ml (mean 285 ng/ml; SD 72) which may have prevented adequate spontaneous ventilation[8] and therefore their technique could be employed only in patients who received IPPV.

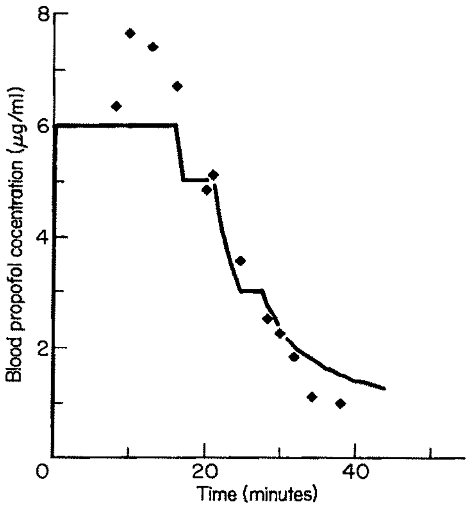

Fig. 5. Predicted and measured blood propofol concentrations during induction and maintenance of anaesthesia in a female patient, age 34 years, weight 59 kg, who underwent ligation of varicose veins. (Continuous line represents predicted values, individual points are measured concentrations.)

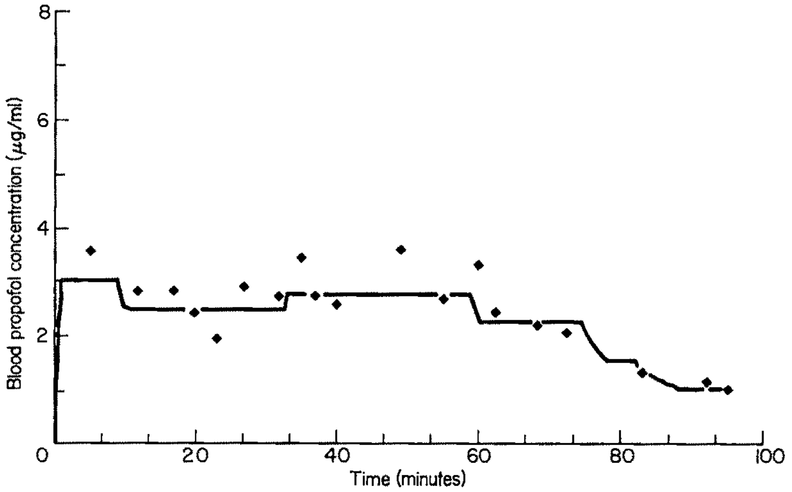

Fig. 6. Predicted and measured blood propofol concentrations during induction and maintenance of anaesthesia in a female patient, age 68 years, weight 65 kg, who underwent cholecystectomy. (Continuous line represents predicted values, individual points are measured concentrations.)

Our anaesthetic technique involved administration of a background infusion of alfentanil and variation of the predicted blood concentration of propofol between 2 and 6 μg/ml to maintain an adequate depth of anaesthesia in response to variations in surgical stimulation. The computer-controlled infusion system produced blood concentrations which correlated closely with those predicted by our model. The pharmacokinetic variables used in the model were obtained from nine male and two female patients with a mean weight of 73.5 kg and mean age of 35 years.[2] Therefore, the lack of complete correlation with our group of 12 male and 21 female patients (mean weight 68.8 kg, mean age 45.2 years) may be anticipated. We found no difference in the correlations of predicted and measured blood concentrations between patients who breathed spontaneously and those who received IPPV.

The use of this computer-controlled infusion system to maintain anaesthesia may be considered similar to that of a calibrated vaporizer, although the predicted blood propofol concentration may be different from the true concentration achieved. A more accurate estimate of the blood concentration of a volatile agent may be obtained because the end-tidal concentration of the volatile agent can be measured. In addition, gross alterations of metabolism, as can occur with patients who exhibit tolerance to alcohol, would be expected to produce a greater discrepancy between the predicted and measured blood concentration of propofol.

The blood propofol concentrations required to produce satisfactory conditions may require minimal alteration during IPPV (Figs 5 and 6), but considerable variation may be needed when patients are breathing spontaneously; we consider this to be the real test of any intravenous anaesthetic technique. In addition, the propofol concentration may be reduced easily when the surgical stimulation is decreased towards the end of the operation. This reduces the amount of propofol in the peripheral compartments and allows the patient to recover more rapidly than if the blood concentration is maintained throughout the procedure at the level necessary to prevent patient response to the maximal surgical stimulation developed during the procedure.

The principal disadvantage of our propofol infusion system is the bulk of the trolley required for the computer. In addition, electrical power has to be supplied continually to prevent loss of data. The Imed 929 pump has the limitation that it can deliver infusion rates only in steps of 1 ml/hour and volumes to the nearest 1 ml. In addition, it requires a volume of 10 ml to prime the cassette and delivery tubing. In spite of these problems, the system has performed satisfactorily in routine clinical practice and greatly simplifies the use of propofol to induce and maintain anaesthesia.

We have now interfaced the Atari computer to the computer-controllable Ohmeda 9000 syringe pump. This should be more satisfactory in that it uses a range of standard syringes and has selectable 'bolus' infusion rates of 1200, 600 and 300 ml/hour. It can deliver an infusion in steps of 0.1 ml/hour and volumes to the nearest 0.1 ml.

The computer-controlled infusion system allows the anaesthetist to select any predicted concentration of propofol at any time during the procedure. This is similar in concept to a vaporizer with which the anaesthetist is already familiar. Maintenance of intravenous anaesthesia can be undertaken with relative ease and anaesthetic depth adjusted as required for the individual patient and surgical procedure.

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Arterial to end-tidal carbon dioxide tension difference during laparoscopy

Magnitude and effect of anaesthetic technique

W. J. BRAMPTON AND R. J. WATSON

Summary

The relationship between arterial carbon dioxide tension and end-tidal carbon dioxide tension was studied in 25 patients during laparoscopy. Thirteen patients received general anaesthesia and 12 epidural anaesthesia. The overall mean difference between arterial and end-tidal carbon dioxide tensions was 0.44 kPa (95% confidence intervals 0.28–0.60 kPa) which was significantly less than that reported in studies during other procedures. The reasons for this difference are probably associated with the physiological changes induced by CO_2 pneumoperitoneum and steep Trendelenburg positioning. The choice of anaesthetic technique did not affect the arterial to end-tidal carbon dioxide tension difference significantly ($p > 0.9$).

Key words

Anaesthetic techniques; inhalational, epidural.
Measurement techniques; capnography.

End-tidal carbon dioxide partial pressure ($P\text{E}'\text{CO}_2$) monitoring is increasingly used during anaesthesia as an indirect measure of arterial carbon dioxide tension ($P\text{aCO}_2$), and the relationship between these two variables is of considerable interest. A number of studies have been performed to evaluate the arterial to end-tidal CO_2 difference ($P(\text{a–E}')\text{CO}_2$) in adults under general anaesthesia (GA), usually for major surgery;[1–6] mean values between 0.46 and 0.70 kPa have been reported.

The value of $P(\text{a–E}')\text{CO}_2$ is dependent upon many factors including the relative distribution of ventilation and perfusion ($\dot{V}/\dot{Q}$) within the lung, changes in functional residual capacity (FRC) and changes in CO_2 production ($\dot{V}\text{CO}_2$). Trendelenburg positioning together with peritoneal insufflation of CO_2 during gynaecological laparoscopy reduce FRC[10] and increase $\dot{V}\text{CO}_2$.[11] There may also be a change in $\dot{V}/\dot{Q}$ distribution due to basal lung compression and redistribution of hydrostatic forces. Thus $P(\text{a–E}')\text{CO}_2$ may be expected to change.

The purpose of the present study was to measure $P(\text{a–E}')\text{CO}_2$ during laparoscopy in order to assess the reliability of $P\text{E}'\text{CO}_2$ as a measure of $P\text{aCO}_2$ in these circumstances. There has also been speculation that the choice of anaesthetic technique may affect $P(\text{a–E}')\text{CO}_2$.[5] Consequently, the effects of general and epidural anaesthesia (EA) were compared.

Methods

Institutional ethics committee approval was obtained and 28 patients were recruited to the study from the patients admitted for day-case laparoscopy. The inclusion criteria were freedom from disabling illness (ASA grade 1 or 2), age between 18 and 60 years and willingness to give written informed consent. The exclusion criteria were pregnancy (unless being terminated), coagulation or platelet abnormalities, lower back pain, injury or deformity, central or peripheral neurological disorder, any infection in the lumbar region, known or suspected adverse reaction to any drug planned for use and any condition which indicated a specific choice of anaesthetic technique for clinical reasons. Each patient chose either GA or EA and was taken to the operating theatre. No premedication was administered.

The patient was positioned supine on the operating table on arrival in theatre and connected to an electrocardiograph (ECG) monitor (lead CM5), automatic blood pressure cuff, pulse oximeter, precordial stethoscope and peripheral nerve stimulator (GA patients only). A 16-gauge intravenous cannula was sited under local anaesthesia and an infusion of compound sodium lactate solution started at a maintenance rate of 7 (ml/kg)/hour for 1 hour and then 3.5 (ml/kg)/hour. Two sets of baseline monitoring readings were taken 5 minutes apart before administration of the

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appropriate standardised anaesthetic. Further monitoring data were recorded every 5 minutes during anaesthesia until the patient left theatre.

Patients who received GA were pre-oxygenated for 3 minutes before anaesthesia was induced intravenously with fentanyl 1–1.5 μg/kg and thiopentone 4–5 mg/kg. Tracheal intubation was accomplished after administration of atracurium 0.5 mg/kg or vecuronium 0.08 mg/kg. Maintenance of anaesthesia was achieved using 60–70% nitrous oxide in oxygen and up to 1.5% isoflurane via a circle system with CO_2 absorber; the fresh gas flow rate was 6–7 litres/minute, and mechanical ventilation was used with a tidal volume of 8–10 ml/kg and a rate of 10–14 breaths/minute to maintain $P\text{E}'\text{CO}_2$ at a stable value less than 4.5 kPa for 10 minutes. These settings were retained for the remainder of the operation.

An epidural catheter was sited at the second or third lumbar interspace under local anaesthesia using loss of resistance to air or saline in patients in the EA group. Compound sodium lactate 15–20 ml/kg was administered as a preload and an epidural test dose of 3 ml 2% lignocaine with 1:200 000 adrenaline was given. The level of block was raised with 5-ml increments of the same agent until a block to pinprick was established from S_4 to $T_{4\text{–}6}$ dermatomes. Epidural fentanyl 1 μg/kg was administered when the anaesthetic block was established to relieve the shoulder pain commonly experienced due to diaphragmatic irritation by insufflated CO_2. Intravenous sedation with midazolam in 1–2-mg increments was given if the patient so desired. Supplemental inspired oxygen was administered if arterial oxygen saturation decreased below 93%.

Systolic hypotension of up to 30% below baseline was treated with an intravenous fluid bolus of 7 ml/kg supplemented by intravenous ephedrine 5 mg if necessary.

$P\text{E}'\text{CO}_2$ was measured using an Allegheny International SARA mass spectrometry system sampling at 100 ml/minute. Gas was sampled continuously from the apparatus end of the tracheal tube in the GA group and measurements were recorded at least every 90 seconds. Gas sampling was from the nasopharynx in the EA group, by means of a fine-bore catheter passed through the nostril under topical anaesthesia, and was instituted at 5-minute intervals to avoid tube blockage by secretions. The $P\text{E}'\text{CO}_2$ was recorded at BTPS from digital hard copy data. A reproducible value (varying by less than 1%) over several samples and a good quality alveolar plateau on the accompanying capnograph were prerequisites for data acceptability. The mass spectrometer was automatically zeroed and recalibrated to an accuracy of better than 0.1% using reference gases before each study, and continuous quality control was applied by an automatic check which ensured that the sum of partial pressures at each analysis fell within 0.2% of ambient atmospheric pressure.

Laparoscopy was performed using a standardised technique. The patient was put into a 30° Trendelenburg position after peritoneal insufflation with CO_2 had started and this was maintained until removal of the laparoscope. Intra-abdominal pressure was monitored continuously and maintained automatically at 1.5 to 2.0 kPa.

Simultaneous measurement of $P\text{E}'\text{CO}_2$ and radial arterial blood sampling were undertaken at the end of the procedure, immediately before removal of the laparoscope (local anaesthesia was used before blood sampling in the EA group). The arterial blood sample was stored in crushed ice until analysis (almost always in less than 5 minutes), at 37°C, using a Corning 175 automatic blood gas machine. This was zeroed and recalibrated against reference gas samples every hour. A nine-point quality control test was performed daily to ensure that performance remained within the manufacturer's specifications. Stated accuracy of CO_2 analysis was 1% at $P\text{CO}_2$ of 4.74 kPa (using tonometered blood) with a precision (1 SD) on replicate analysis of 0.10 kPa at the same $P\text{CO}_2$ (manufacturer's data from field tests).

Table 1. Weight, age, baseline monitoring results and duration of procedures. Data displayed as mean (SD) except O_2 saturation which is median (range). There was no statistical difference between groups. GA, general anaesthesia; EA, epidural anaesthesia.

	GA $n = 13$	EA $n = 12$
Weight (kg)	69.2 (28.9)	67.6 (17.9)
Age (years)	27.9 (5.8)	32.8 (4.4)
Systolic arterial pressure (mmHg)	127.6 (18.6)	123.9 (13.1)
Diastolic arterial pressure (mmHg)	75.6 (11.2)	76.5 (7.7)
Heart rate (beats/minute)	77.2 (9.6)	77.5 (11.8)
Oxygen saturation (%)	100 (99–100)	99.5 (98–100)
Duration of anaesthesia (minutes)	44.3 (12.3)	55.2 (13.4)
Duration of Trendelenberg (minutes)	19.3 (9.1)	16.1 (5.3)

The two groups were compared for statistical differences and $p < 0.05$ was taken as indicating significance. The mean and standard deviation were calculated and parametric statistical tests used for all data, except oxygen saturation. Paired Student's *t*-test was used within groups for statistical comparison and either Student's *t*-test or a modified *z*-test between groups, depending on whether the variance ratio was insignificant or significant.[7] The median and range of oxygen saturation data were calculated and the Mann–Whitney test was used for comparison. The correlation between $P\text{aCO}_2$ and $P\text{E}'\text{CO}_2$ was tested by calculation of the correlation coefficient with $P\text{E}'\text{CO}_2$ as the dependent variable.

Ninety-five percent confidence intervals (CI) were derived for the mean and range of $P(\text{a–E}')\text{CO}_2$. Correlation coefficients were calculated with $P(\text{a–E}')\text{CO}_2$ as the dependent variable and $P\text{aCO}_2$, age, weight, duration of anaesthesia and duration of Trendelenburg position as independent variables.

Results

Thirteen patients received GA and 15 EA. However three of the EA group were excluded from the study because blood gas analysis failed for technical reasons. The remaining patients in the two groups were comparable in respect of weight, baseline monitoring results, duration of anaesthesia and duration of Trendelenburg positioning

Table 2. Intra-operative monitoring data; mean, maximum and minimum values as mean (SD) except oxygen saturation which is median (range) for maximum and minimum only. Significant differences between EA and GA groups; *p<0.05, **p<0.01. GA, general anaesthesia; EA, epidural anaesthesia.

Parameter (units)	Mean		Maximum		Minimum	
	GA	EA	GA	EA	GA	EA
Systolic arterial	133.6	122.5	161.1	144.1	107.5	105.8
pressure (mmHg)	(19.8)	(11.2)	(23.6)	(17.5)	(18.9)	(11.8)
Diastolic arterial	84.7	72.8*	107.9	88.2**	62.2	59.7
pressure (mmHg)	(13.4)	(7.4)	(18.1)	(10.3)	(9.8)	(9.3)
Heart rate	85.8	93.4	103.6	108.1	68.2	75.9
(beats/minute)	(10.4)	(8.0)	(14.7)	(11.7)	(9.8)	(9.6)
Oxygen	N/A	N/A	100	100	98.0	96.5
saturation (%)			(100)	(99–100)	(94–100)	(89–100)

(Table 1). The EA patients were slightly but not significantly older.

Systolic arterial pressure and heart rate were not significantly different between the groups during the procedure. Diastolic arterial pressure was lower in the EA group (Table 2).

Individual results of $P\mathrm{CO_2}$ measurements are shown in Table 3. The mean $P\mathrm{aCO_2}$ in the GA group was significantly lower than in the EA group (Fig. 1). The mean $P\mathrm{E'CO_2}$ in both groups was lower than the mean simultaneous $P\mathrm{aCO_2}$. The correlation coefficient (SE) between $P\mathrm{aCO_2}$ and $P\mathrm{E'CO_2}$ was 0.84 (0.11) which was highly significant ($p < 0.001$).

The mean $P(\mathrm{a{-}E'})\mathrm{CO_2}$ was 0.44 kPa (CI 0.23–0.65) in the GA group and 0.43 kPa (CI 0.14–0.72) in the EA group; these values were not significantly different ($p > 0.9$). $P(\mathrm{a{-}E'})\mathrm{CO_2}$ was negative in two individuals (Table 3 and Fig. 2). The overall mean $P(\mathrm{a{-}E'})\mathrm{CO_2}$ (both groups combined) was 0.44 kPa (CI 0.28–0.60) with CI for the range of −0.36 to +1.24 kPa.

There were no significant relationships ($p > 0.2$ in all cases) in either separate or combined groups between $P(\mathrm{a{-}E'})\mathrm{CO_2}$ and $P\mathrm{aCO_2}$, age, weight, duration of anaesthesia or duration of Trendelenburg position.

Discussion

The mean $P(\mathrm{a{-}E'})\mathrm{CO_2}$ during laparoscopy was 0.44 kPa with 95% confidence intervals of 0.28–0.60 kPa. Our results predict that 95% of patients will have a $P\mathrm{aCO_2}$ between 0.36 kPa lower and 1.24 kPa higher than $P\mathrm{E'CO_2}$. The mean value of $P(\mathrm{a{-}E'})\mathrm{CO_2}$ was similar in patients who received two fundamentally different anaesthetic techniques and was independent of duration of anaesthesia or surgery.

The study design was not ideal because it was impossible to randomise the allocation of anaesthesia (most patients had a strong preference for either EA or GA) or to make the study blind. However, observer bias was avoided by recording $P\mathrm{E'CO_2}$ before blood gas analysis and by taking all data from digital hard copy. In addition, despite

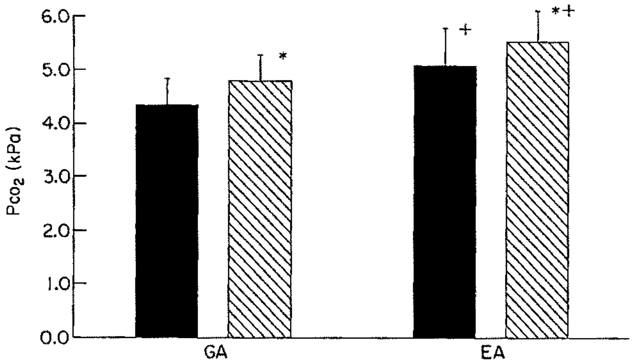

Fig. 1. Mean partial pressures of $\mathrm{CO_2}$ in EA and GA groups. Error bars show SD. *$p < 0.001$ $P\mathrm{E'CO_2}$ (■) compared with $P\mathrm{aCO_2}$ (▨) in the same groups; $^{+}p < 0.001$ compared with GA group.

Table 3. Individual values of $P\mathrm{CO_2}$. See Figures 1 and 2 for statistical comparisons. Note: EA patients 11–13 withdrawn due to failure of blood gas analysis. GA, general anaesthesia; EA, epidural anaesthesia.

Patient number	$P\mathrm{aCO_2}$ kPa	$P\mathrm{E'CO_2}$ kPa	$P(\mathrm{a{-}E'})\mathrm{CO_2}$ kPa
GA			
1	5.3	5.6	−0.3
2	4.7	4.4	0.3
3	4.4	4.0	0.4
4	4.7	4.4	0.3
5	4.7	3.9	0.8
6	4.9	4.4	0.5
7	5.9	4.7	1.2
8	4.0	3.7	0.3
9	4.8	4.4	0.4
10	4.8	4.3	0.5
11	4.3	4.0	0.3
12	4.4	3.9	0.5
13	5.2	4.7	0.5
Mean	4.78	4.34	0.44
(SD)	(0.49)	(0.49)	34)
EA			
1	5.2	4.7	0.5
2	6.0	5.7	0.3
3	5.5	4.7	0.8
4	5.5	4.1	1.4
5	5.3	4.4	0.9
6	4.9	4.9	0
7	5.5	4.9	0.6
8	5.7	5.7	0
9	5.6	5.3	0.3
10	6.9	6.7	0.2
14	5.6	5.1	0.5
15	4.5	4.8	−0.3
Mean	5.52	5.08	0.43
(SD)	(0.58)	(0.69)	(0.46)
All subjects			
Mean	5.13	4.70	0.44
(SD)	(0.65)	(0.70)	(0.39)

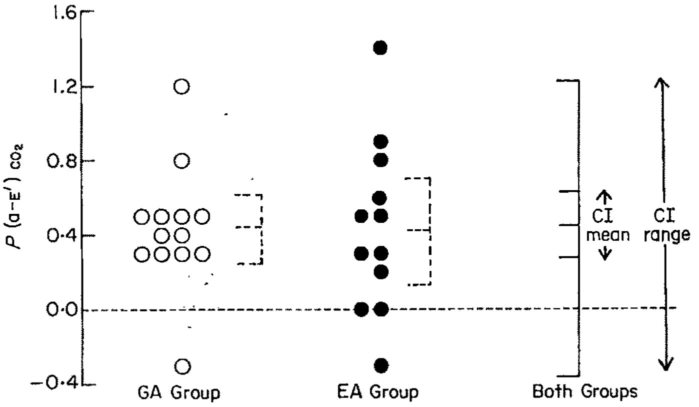

Fig. 2. Values of $P(\text{a-E}')\text{CO}_2$ for the two patient groups. The dotted bars (- - -) show the means and 95% confidence intervals (CI); the solid bars (——) show the overall mean and 95% confidence intervals for mean and range.

nonrandomisation, the two groups were comparable in respect of demographic and baseline data. Smoking habits, which may also alter $P(\text{a-E}')\text{CO}_2$ were not recorded. There was a statistically insignificant higher age in the EA group but since $P(\text{a-E}')\text{CO}_2$ was independent of age in this study such a difference is unlikely to have affected the results. Nasopharyngeal sampling was used in the EA group as the least invasive, reliable way of obtaining true expired gas in a conscious subject. It is conceivable that gas mixing and dilution may have occurred but the prerequisite for a convincing alveolar plateau to be present with no downward gradient means that the samples were almost certainly undiluted. Such a plateau could be maintained in the presence of dilution only if the entrainment rate of diluent gas decreased at the same rate as expiratory flow. Such an event is unlikely because the gas sampling rate was constant.

Ethical considerations prevented repeated arterial sampling and it was therefore impossible to establish baseline values or temporal variability of $P(\text{a-E}')\text{CO}_2$. However, the majority of previous studies during anaesthesia have derived mean values for $P(\text{a-E}')\text{CO}_2$ which are close to, or exceed, the upper 95% confidence interval of the mean in the present study.[1-6]

The authors of two studies performed during Caesarean section[6] and post-partum minilaparotomy for tubal ligation[8] reported mean $P(\text{a-E}')\text{CO}_2$ values below the lower 95% confidence limit for the mean in the present study. Shankar *et al.*[6] used a control group of young (mean age 26 years), nonpregnant, ASA 1, females who underwent abdominal hysterectomy and found a mean $P(\text{a-E}')\text{CO}_2$ of 0.70 kPa (95% confidence interval 0.60–0.79 kPa). Thus there is evidence that $P(\text{a-E}')\text{CO}_2$ is lower during laparoscopy than during other surgical procedures in nonparturient women but not as low as during Caesarean section or post-partum tubal ligation.

The finding that $P(\text{a-E}')\text{CO}_2$ was similar in the EA and GA groups was initially unexpected because a number of authors have speculated that differences in GA technique alone may alter this difference.[4,5] It has been shown elsewhere that GA with paralysis increases alveolar deadspace and the number of high $\dot{V}/\dot{Q}$ zones[12] whereas EA has no effect.[13] Fletcher has suggested that hyperventilation (as in the GA group) increases $P(\text{a-E}')\text{CO}_2$.[9] Opposing these factors would be the physiological effects of laparoscopy, the similar cardiovascular status of the two groups (although the circulating volume was probably greater in the EA group) and the likelihood that the EA group had a higher respiratory rate and lower tidal volume (factors which also increase $P(\text{a-E}')\text{CO}_2$).[2] The two groups were not strictly comparable but it is apparent that the anaesthetic technique *per se* does not greatly alter $P(\text{a-E}')\text{CO}_2$ in this situation.

Some authors[6,8] have performed regression analysis to produce an equation in the form:

$$P\text{E}'\text{CO}_2 = \text{a} + \text{b}.P\text{aCO}_2$$

However this can be rearranged as

$$P(\text{a-E}')\text{CO}_2 = P\text{aCO}_2.\ (\text{l-b})\text{-a}$$

which implies a dependence of $P(\text{a-E}')\text{CO}_2$ upon $P\text{aCO}_2$ that does not apparently exist. Therefore regression analysis was not performed in this study.

In conclusion, this study during laparoscopy has demonstrated a mean $P(\text{a-E}')\text{CO}_2$ higher than found in awake controls[5] and anaesthetised parturients but lower than during other surgery. For clinical purposes $P(\text{a-E}')\text{CO}_2$ is unaffected by the choice of anaesthetic technique, duration of anaesthesia or surgery, or the patient's weight, age or $P\text{aCO}_2$. Monitoring of $P\text{E}'\text{CO}_2$ during laparoscopy can be used to reflect $P\text{aCO}_2$ but an increase in $P\text{E}'\text{CO}_2$ is likely to occur at the start of the procedure due to a decrease in $P(\text{a-E}')\text{CO}_2$.

Further studies could examine the time course and magnitude of $P(\text{a-E}')\text{CO}_2$ with head-down positioning and with CO_2 pneumoperitoneum together with associated changes in lung volumes and $\dot{V}/\dot{Q}$ ratios.

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Anaesthesia, 1990, Volume 45, pages 215–217

CASE REPORT

Acute viral myocarditis

A death associated with anaesthesia

W. J. BRAMPTON AND R. H. JAGO

Summary

The death of a 35-year-old woman in the immediate postoperative period as a result of undiagnosed acute viral myocarditis is described. The presentation, diagnosis and course of the disease is discussed. It is recommended that wider use be made of routine electrocardiographs as a screening test.

Key words

Heart; myocarditis, viral.
Complications; death.

Viral myocarditis is frequently asymptomatic and is a well recognised cause of sudden death in apparently healthy people aged less than 40 years. An initially unexplained death is reported in a young woman immediately after surgery for a prolapsed lumbar intervertebral disc. Microscopic examination of the myocardium after autopsy revealed diagnostic histological signs of acute myocarditis of viral origin.

Case history

A 35-year-old woman who had a prolapsed lumbar intervertebral disc was admitted for laminectomy and nerve root decompression. She was somewhat apprehensive and confined to bed by severe back pain. She gave no history of allergy, but in the past had suffered intermittent attacks of asthma during which she inhaled aerosolised salbutamol. She was taking Motival (nortriptyline 10 mg plus fluphenazine hydrochloride 0.5 mg) twice daily, Ponstan (mefenamic acid 250 mg) three times a day and Tylex (paracetamol 500 mg plus codeine phosphate 30 mg) four hourly as required. She was well built and weighed 65 kg. Her pulse was regular, of good volume, with a rate of 80 beats/minute; her blood pressure (BP) was 120/80 mmHg and on auscultation her chest was clear. Urinalysis revealed some blood, the patient was menstruating, but was otherwise normal. No other pre-operative investigations were considered indicated or performed.

The next morning, one hour after premedication with intramuscular papaveretum 15 mg and hyoscine 0.3 mg, general anaesthesia was initiated with deliberate hypotension to facilitate surgery. Induction was performed with intravenous thiopentone 350 mg, muscle relaxation achieved with tubocurarine 35 mg and, after tracheal intubation, anaesthesia was maintained by controlled ventilation of her lungs with 33% oxygen with halothane in nitrous oxide. The blood pressure was initially settled using 2.5% halothane for 10 minutes followed by 1 to 1.5% for maintenance. Halothane was discontinued 10 minutes before the end of surgery. Intra-operative pulse, BP, electrocardiogram (ECG), end-tidal carbon dioxide and expired volume were monitored.

The patient was placed face down in the knee–elbow position and ECG electrodes were attached to the shoulders and back. Surgery was completed in 45 minutes with minimal blood loss. Peroperatively 350 ml of compound sodium lactate solution was infused intravenously and the systolic BP was maintained at a median of 70 mmHg (range 65–85) with a median heart rate of 80 beats/minute (range 75–85). End-tidal CO_2 was in the range 4.0–4.5% with no sudden variations.

The patient was turned onto her back on completion of surgery and the residual neuromuscular blockade was reversed with intravenous neostigmine 2.5 mg combined with atropine 1.2 mg. Normal spontaneous breathing was rapidly established on 100% oxygen and systolic BP increased to 100 mmHg. The unconscious patient was transferred after extubation the short distance to the recovery room where oxygen was administered at 4 litres/minute via a Henley MC facemask. Her airway was patent and breathing clinically normal in transit. The patient suddenly became dyspnoeic with gasping breathing and bradycardia. She rapidly became pale, mottled and cyanosed despite immediate ventilation with 100% oxygen, at first via an

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anaesthetic facemask and then tracheal tube. Full cardiopulmonary resuscitation was instituted when intravenous atropine failed to reverse the bradycardia.

The ECG showed grossly abnormal, widened, QRS complexes with no associated arterial pulsations. Plasma volume expansion was achieved with intravenous compound sodium lactate and gelatin solutions. Drugs were administered via an internal jugular line and by the intracardiac route. Repeated standard doses of atropine, isoprenaline, calcium chloride and adrenaline were given and after blood gas analysis (pH 7.07) small increments of sodium bicarbonate were also infused. A second internal jugular long line was inserted in order to aspirate the right ventricle in case of air embolism, but only blood was forthcoming. The patient failed to respond in any way despite these measures and attempts at resuscitation were abandoned after one hour.

Postmortem revealed no evidence of air embolism, haemorrhage, pneumothorax, myocardial or cerebral infarction, or any anaesthetic or surgical error. A toxicology screen confirmed normal therapeutic blood concentrations of anaesthetic agents, halothane 17 mg/litre (usual peroperative levels are 80–260 mg/litre), thiopentone not detectable, pentobarbitone (metabolite of thiopentone) 0.17 mg/litre, free morphine undetectable, morphine glucuronide 0.03 mg/litre. However, histological examination of the myocardium demonstrated focal areas of degeneration associated with an inflammatory cell infiltrate. This was predominantly lymphocytic and plasma cellular, but a significant polymorph population was also present. These appearances were reported as consistent with a focal acute myocarditis of viral origin. The subsequent Coroner's inquest accepted this diagnosis and returned a verdict of death from natural causes.

Discussion

Viral myocarditis is frequently asymptomatic and its incidence in the general population is therefore unknown. It is predominantly a disease of young people and over 50% of reported cases occur in those under 40 years of age;[1–4] it is a well recognised cause of sudden death in this age group.[5] A multitude of viruses have been implicated (Table 1), but Coxsackie B is by far the commonest cause.[1,6] A vague history of a recent or concurrent influenza-like illness is frequently elicited[7] and chest pain occurs occasionally. In some cases myocardial dysfunction may result in arrhythmias, congestive cardiac failure and in the long term dilated cardiomyopathy.[8,9] Endomyocardial biopsy has been used to confirm the diagnosis.[10] In the case reported here the symptoms may have been masked by the initial conservative management of the patient's prolapsed intervertebral disc.

Diagnosed myocarditis is always accompanied by ECG changes[2,5] and on examination these may well be the only abnormal findings.[8] Invariably, there is S-T elevation and T wave flattening or inversion in all leads. In addition there may be low voltage QRS complexes, transient Q waves, ectopic beats (usually ventricular), atrial fibrillation, atrioventricular conduction disorders and bundle branch block (usually left).[1–3,5,9]

Table 1. Principal causes of viral myocarditis.[9]

Coxsackie A and B
Echovirus
Adenovirus
Influenza
Varicella
Poliomyelitis
Mumps
Rabies
Viral hepatitis
Rubella
Rubeola
Infectious mononucleosis
Cytomegalovirus
Arbovirus A and B
Variola and vaccinia
Viral encephalitis
Yellow fever
Herpes simplex

Several reviews have indicated that pre-operative ECGs are of no value as a screening test for ischaemic heart disease in asymptomatic patients under 50 years of age with a normal cardiovasculature.[11–13] We, like many other Divisions of Anaesthetics, have made a policy decision not to order this investigation in such patients and as a consequence one was not performed in the case reported. The peroperative ECG revealed no abnormality, but it should be noted that this was performed using a nondiagnostic monitor and only one lead was observed taken from unusual electrode positions on the patient's shoulder and back.

A surprising aspect of this case is that cardiac arrest did not occur until the recovery period. Indeed, there was no suggestion of cardiovascular instability up until the moment of arrest. Hypoxaemia due to hypoventilation or respiratory obstruction can be ruled out in this case in view of pre-oxygenation before extubation, the patient's good tidal volume, very short transfer time to the recovery ward and subsequent administration of oxygen, all with continual anaesthetic supervision. A possible explanation is that the knee–elbow position results in occlusion of the circulation to the lower limbs, and thus produces a reduced vascular bed for the heart to perfuse. However, when the patient was returned to the supine position at the end of surgery reperfusion of the lower limbs would have led to a sudden decrease in systemic vascular resistance and consequently venous return. In addition, the revascularisation of hypoxic tissue would have resulted in a decrease in arterial pH which, combined with the effects of anaesthetic myocardial depression, could have been sufficient to precipitate arrest. The lack of response to all resuscitative measures proved indicative in retrospect of the underlying primary myocardial disease.

Neither the pathologist nor Coroner implicated the anaesthesia or surgery in the patient's demise. However, death was closely related to the operation, during which deliberate hypotension was induced using cardiodepressant anaesthetic agents. Had it been known that the woman had concurrent acute myocarditis the surgery could have been deferred and further conservative treatment instituted.

Routine ECG screening before operation would ensure that asymptomatic myocarditis did not pass unnoticed. It is impossible to assess how many cases would be detected since the prevalence of the disease is unknown. However, many precautions are already undertaken in order to minimise further what is acknowledged to be a very low incidence of unexpected peri-operative deaths.[14,15] The cost per life saved is vast, but considered justifiable by the Association of Anaesthetists of Great Britain and Ireland.[16] Our experience in this case suggests that serious consideration should be given to an extension of this principle by the re-institution of routine pre-operative ECGs in all patients who are due to be subjected to significant physiological stress during anaesthesia and surgery.

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CASE REPORT

Painless loss of vision after transurethral resection of the prostate

D. RUSSELL

Summary

A 74-year-old man developed complete loss of vision after transurethral prostatectomy under spinal anaesthesia. Eyesight returned to normal over the next 12 hours. A direct inhibitory effect on the retina caused by glycine absorbed with the irrigation fluid is suggested as a possible cause.

Key words

Complications; glycine absorption.
Eye; blindness.

The features of the transurethral resection syndrome associated with absorption of bladder irrigation fluid are well documented.[1-4] A number of authors have reported blurring of vision, even transient blindness, after transurethral prostatectomy.[5-8] Recent research[9] supports the suggestion that it may be because of a toxic effect of glycine absorbed with the irrigation fluid.

Case history

A 74-year-old noninsulin-dependent diabetic with a history of chronic simple glaucoma presented for routine prostatectomy. He had recently had a trabeculectomy performed on his right eye under general anaesthesia, without complication.

Pre-operative assessment revealed no significant abnormalities of the cardiovascular or respiratory systems. Chest X ray was normal as was ECG, except for some left axis deviation; blood pressure was 170/100 mmHg.

His diabetes was well controlled on glibenclamide 10 mg in the morning and 5 mg in the evening. Other medication included dexamethasone drops to the right eye and pilocarpine, timolol and dipivefrin drops to the left eye. Full blood count was normal, with a haemoglobin concentration of 14.2 g/dlitre. Creatinine was raised at 166 μmol/litre, but serum biochemistry was otherwise normal. Random blood glucose was 12.0 mmol/litre.

He was fasted overnight and his morning glibenclamide was withheld. His eyedrops were continued and a standard glucose/insulin/potassium regimen was started to maintain blood glucose between 5 and 15 mmol/litre. He proceeded to theatre for transurethral prostatectomy under spinal anaesthetic, after oral premedication with temazepam 20 mg. Three millilitres of 0.5% heavy bupivacaine were introduced at $L_{2/3}$ through a 25-gauge needle after preloading with 500 ml compound sodium lactate to produce a rapid block to T_{10} bilaterally. Blood pressure was maintained above 130/70 mmHg throughout without vasopressors. Additional inspired oxygen was provided (4 litres/minute via Hudson mask) and surgery started, using 1.5% glycine as irrigation fluid. The glucose/insulin/potassium regimen was continued and the compound sodium lactate changed to polygeline to replace blood loss.

The patient became mildly agitated 30 minutes after surgery began, and cefuroxime 750 mg was administered to treat possible bacteraemia, which is a common occurrence in transurethral prostatic resection.[4] He began to feel unwell and 15 minutes later complained of facial warmth, swelling around the eyes and frontal headache. Examination was unremarkable, and there was no evidence of periorbital oedema or cardiorespiratory instability. The polygeline was replaced by normal saline, since the symptoms could possibly have been allergic in origin, and chlorpheniramine 10 mg was administered. The patient then began to feel nauseated, vomited bile-stained fluid and became increasingly agitated. He was given metoclopramide 10 mg.

The operation finished after an hour, whereupon he complained of dyspnoea, although auscultation was normal and there was no stridor. He was given hydrocortisone 100 mg, again on the assumption that the entire episode could have been allergic in origin. There was a brief run of ventricular bigeminy which settled spontaneously before transfer to the recovery ward. Blood pressure and perfusion were unaffected.

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Table 1. Biochemistry and haematology results before and after operation.

Time after operation (hours)	Before operation	0	5	16	40	64
Sodium (mmol/litre)	136.1	118.2	126.4	128.3	138.4	140.1
Potassium (mmol/litre)	4.4	4.2	3.8	3.8	3.9	4.7
Bicarbonate (mmol/litre)	28.9	20.2	22.4	23.0	23.6	26.1
Urea (mmol/litre)	4.8	3.9	7.4	9.0	6.0	4.5
Creatinine (μmol/litre)	166.0	89.0	108.0	110.0	111.0	118.0
Glucose (mmol/litre)	12.0	14.6	14.6	11.9	15.5	17.0
Total protein (g/litre)	66.4	54.0	51.2	53.0	55.7	61.5
Albumin (g/litre)	40.2	30.7	30.5	32.2	33.8	37.0
Haemoglobin (g/dlitre)	14.2	13.1	11.3	10.3	9.6	10.0
Haematocrit (%)	45.0	40.4	34.3	29.7	29.6	31.2
White blood cell count (× 10^9/litre)	8.3	11.2	16.4	11.3	8.4	7.7
Platelets (× 10^9/litre)	246.0	238.0	223.0	204.0	191.0	213.0

The patient calmly declared shortly after arrival in the recovery area that he had become completely blind. Later questioning revealed amnesia for the latter half-hour of the resection, despite the fact that his only sedation had been temazepam premedication. Examination confirmed complete visual loss, but was otherwise unremarkable. The left pupil remained constricted by his eyedrops, while the right barely reacted to light. Fundoscopy revealed no gross abnormality; in particular there was no evidence of papilloedema. Serum biochemistry showed hyponatraemia and hypoproteinaemia (Table 1) which suggested significant absorption of the glycine irrigation fluid.[10,11]

He was transferred to the Intensive Care Unit where the infusion of normal saline was continued at the rate of 2 litres over 24 hours. The glucose/insulin/potassium regimen was replaced by an insulin sliding scale overnight. Two hours after operation his vision began to return, and he could see light and shapes. At 3 hours, when seen by a consultant ophthalmologist, he could count fingers, and by next morning his vision was subjectively back to normal. Serum biochemistry returned towards pre-operative values over the next 48 hours and he made an uneventful recovery.

Discussion

The aetiology and features of the transurethral resection syndrome have been reported extensively.[1-4,12-16] It is thought that all patients who have transurethral prostatic surgery absorb irrigation fluid, at a rate of 10–30 ml/minute.[17] The total amount absorbed is dependent on the duration of the resection, the extent to which the prostatic venous sinuses are opened, the hydrostatic pressure of the irrigation fluid and the venous pressure at the irrigant–blood interface.[18]

This patient developed signs and symptoms of the transurethral resection syndrome during the operation. The cause of the visual loss remains unclear. The ophthalmologist was unable to reach a firm diagnosis. He found that the media were clear 3 hours after operation; the discs were cupped as previously, the retinal arterioles rather attenuated and intra-ocular pressures acceptable at 16 mmHg (right) and 24 mmHg (left). His suggestion was that bilateral optic nervehead or occipital cortical ischaemia had occurred, due to hypotension, vasospasm or embolus.

Blurring of vision is a recognised feature of the transurethral resection syndrome.[10] Peters and his colleagues[19] studied intra-ocular pressure after transurethral prostatic resection and concluded that none of their patients had increases in intra-ocular pressure large enough to be considered pathological. Defalque and Miller suggested oedema of the occipital cortex as a likely cause,[7] a view supported by Appelt *et al.*[8]

Cranial nerve palsies, in particular those that affect the sixth nerve, have been reported previously as an

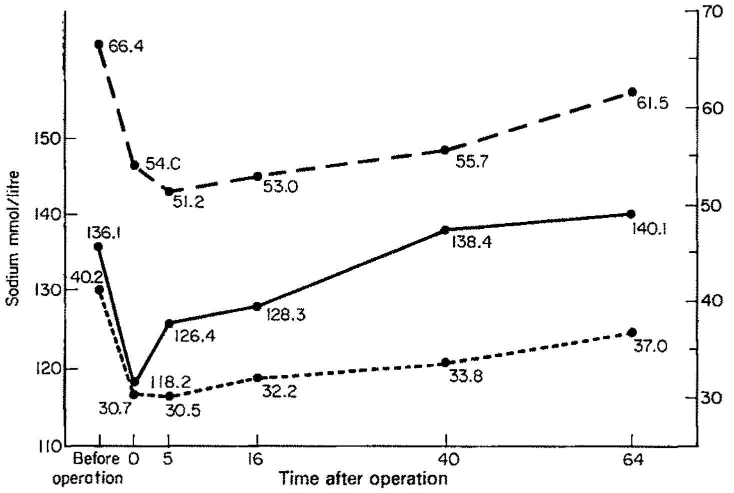

Fig. 1. Serum sodium (———) total protein (– – –) and albumin (- - - - - -) pre- and postoperatively.

uncommon complication of spinal anaesthesia.[20–22] These are thought to be associated with reduced intracranial pressure caused by leakage of cerebrospinal fluid through the dural puncture site, and together with postspinal headache tend to occur hours after the procedure.[22–24] It is considered most unlikely that the sudden blindness in this case was related to spinal anaesthesia.

More recently, interest has focused on glycine as a possible cause of visual disturbances associated with transurethral surgery. A review of the literature reveals one patient who had temporary complete blindness, and a number of others where visual acuity was temporarily reduced to perception of light only, after transurethral prostatectomy using glycine irrigation fluid.[5,6,12] In two of these cases serum glycine was measured in the immediate postoperative period and was found to be greater than 13 500 μmol/litre. Vision returned over the subsequent 12 hours as the serum glycine decreased towards normal (170–330 μmol/litre).[6] A direct action of glycine on the retina was postulated as a cause for the visual loss, while it was suggested that the apparent calm under stressful circumstances was due to a GABA/benzodiazepine-like effect on the central nervous system. The present case is strikingly similar to these previous reports.

Glycine is a nonessential amino acid with a molecular weight of 75, which acts as an inhibitory neurotransmitter in the spinal cord, brainstem, diencephalon and the retina.[25,26] Oxidative deamination in the liver and kidneys produces glyoxylic acid and ammonia, which has itself been implicated as a cause for some of the central nervous system manifestations of the transurethral resection syndrome.[27–29] Intravitreal injection of glycine in rabbits produces an inhibitory effect on the electroretinogram for up to 24 hours.[30] Wang *et al.*[9] recorded electroretinograms and visual evoked potentials before and immediately after transurethral prostatectomy under spinal anaesthesia, using 1.5% glycine as irrigation fluid. Four patients out of 17 developed symptomatic visual disturbance and loss of oscillatory potentials on electroretinogram associated with serum glycine levels greater than 4000 μmol/litre and they concluded that 'high serum levels of glycine are mainly responsible for the visual changes described in the transurethral prostatectomy syndrome'. The patients with hyperglycinaemia and electroretinographic changes were also hyponatraemic, and they were unable to discount this completely as a contributing factor. However, the changes were similar to those that occurred in animal experiments where the glycine level was raised artificially while serum sodium remained normal.

In this case there remains the possibility that the blindness could have been caused by oedema of the occipital cortex, or part of a conversion reaction, but whatever the cause of visual impairment after transurethral resection of the prostate a toxic effect of absorbed glycine cannot be excluded. It is comforting to note that spontaneous return to normality within 24 hours has occurred in every case reported to date.

Acknowledgments

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Anaesthesia, 1990, Volume 45, pages 222–224

CASE REPORT

Respiratory obstruction after posterior fossa surgery

R. HOWARD, A. MAHONEY AND A. C. THURLOW

Summary

We report a case of acute upper airway obstruction after tracheal extubation 24 hours after surgery. The respiratory complications of surgery for posterior fossa lesions are discussed.

Key words

Anaesthesia; neurosurgical.
Complications; airway obstruction, apnoea.

This is a report of respiratory obstruction after posterior fossa surgery. Several case reports have recently appeared on this subject, but the sequence of events seen in this patient is one which we have not met previously in this busy neurosurgical unit. Respiratory complications after posterior fossa surgery although common, are not considered adequately by standard text books, and an up-to-date review of the subject is appropriate.

Case history

A 41-year-old man presented for further surgery to a choroid plexus papilloma of the 4th ventricle. Three years earlier he was admitted with dysarthria, ataxia and bulbar dysfunction, and underwent surgical removal of the majority of the papilloma and radiotherapy to a small amount of residual tumour which was unresectable. He was discharged home after this with no progression of his symptoms until 2 months before the present admission.

He complained of some further change in his speech, difficulty in swallowing solids and a tendency to fall to the right. He had mild dysarthria, incoordination of the right upper limb and abnormal gait with falling to the right, moderate bulbar dysfunction with reduced mobility of the tongue, reduced palatal movement and decreased pharyngeal sensation. Computer assisted tomography showed recurrence of the original tumour in the 4th ventricle.

Anaesthetic management

Premedication was with glycopyrronium 0.2 mg. Anaesthesia was induced with thiopentone 350 mg, vecuronium 10 mg and fentanyl 100 μg and his trachea was intubated with a 9.0-mm oral, cuffed, latex-armoured tracheal tube; a nasogastric tube was passed. An intravenous infusion was established, arterial pressure monitored directly and central venous pressure measured with a catheter inserted from the right antecubital fossa. Anaesthesia was maintained with nitrous oxide in oxygen 30% and isoflurane 0.5% with further increments of fentanyl. Arterial oxygen saturation was assessed by pulse oximetry, end-tidal carbon dioxide monitored and a precordial Doppler ultrasound transducer attached. The patient was elevated to the sitting position by increments; blood pressure and central venous pressure were maintained by infusion of colloids. Surgery lasted approximately 4 hours. Conditions were mostly stable intra-operatively except during dissection around the final remnants of the tumour near the floor of the 4th ventricle. This was associated with mean arterial pressure rising from 70 to 170 mmHg accompanied by sinus tachycardia of 140 beats/minute. It was decided, as a result of the adrenergic response to final tumour dissection and the pre-existing bulbar dysfunction, to leave the tracheal tube in place after operation. The orotracheal tube was replaced with a PVC nasotracheal tube at the end of the procedure. No obvious abnormality of the upper airway was apparent at this time, and after reversal of the residual neuromuscular block the patient was transferred to the intensive care unit. Here he maintained satisfactory blood gases and breathed spontaneously with an $F\text{I}O_2$ 0.4. The next day he was fully awake and appropriately responsive to command. Examination confirmed impaired bulbar function with reduced mobility of the tongue and weak pharyngeal reflexes, similar to his

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status before operation. A trial of extubation was therefore undertaken. The patient was extubated sitting upright and leaning forwards after pre-oxygenation and pharyngeal suction. Total inspiratory obstruction followed; there was no air entry in spite of vigorous respiratory effort. The obstruction was not relieved by insertion of an oropharyngeal airway. Rapid arterial desaturation occurred followed by a grand mal fit, which was terminated by intravenous diazepam 10 mg followed by intravenous suxamethonium 100 mg and reintubation. Laryngoscopy before intubation showed a normal airway with mildly oedematous vocal cords which were fully abducted. He recovered rapidly, and was managed breathing spontaneously through a T-piece until the next day when elective tracheostomy was performed. Fibreoptic laryngoscopy under local anaesthesia with the patient breathing spontaneously, showed a normal glottis with cords lying in a neutral position.

He developed a periodic pattern of breathing which culminated in long apnoeic periods whilst he was awake and sleep apnoea which required nocturnal ventilatory support (Ondine's curse). His condition did not respond to attempted respiratory stimulation with medroxyprogesterone, doxapram, or aminophylline and he required nocturnal positive pressure ventilation for 32 days until control of ventilation returned spontaneously. He had gastric stasis during this time; this prevented enteral feeding for 2 weeks. His heart rate and blood pressure were labile with spontaneously resolving periods of hypotension. Three months later he continues with a tracheostomy. Deflation of the cuff produces marked upper airway obstruction with stridor.

Discussion

A number of respiratory complications after posterior fossa surgery have been described, although the subject is not well covered in standard texts. Potentially fatal, these disorders are in three discernible categories: mechanical obstruction, central respiratory, or neuromuscular dysfunction.

Mechanical obstruction

Upper airway obstruction due to macroglossia after posterior fossa surgery was first reported in 1974.[1] This condition seems to occur at between 0 and 36 hours after operation, most often immediately after surgery.[2] There is massive swelling of the tongue causing airway obstruction, which necessitates tracheal intubation as soon as the diagnosis is suspected and is generally followed by tracheostomy. The condition resolves spontaneously days or months later. A number of causes are proposed: most of them relate to posture during surgery,[3] the sitting position is particularly implicated. Venous obstruction, thrombosis, local trauma and more recently a neurogenic cause[2] are also suggested.

Central respiratory dysfunction

Automatic control of respiration is regulated from the reticular formation of the medulla with pathways in the ventrolateral portion of the spinothalamic tracts in the cervical cord. Two pontine areas can also be identified, the so-called apneustic and pneumotaxic centres, and the integrity of this system is important for normal ventilation.

The occurrence of central disorders of respiratory control after posterior fossa surgery are well recognised and vary from minor disturbances including apnoea, to total loss of the automaticity of respiration, sometimes referred to as Ondine's curse.[4]

The majority of cases in the literature show the condition to be recoverable after a variable period (days to months) of ventilatory support.[4-7] Various adjuncts to aid recovery have been tried including doxapram infusion,[8] medroxyprogesterone injection[9] and acetazolamide,[10] with varying success. Phrenic nerve stimulation is used if spontaneous recovery does not occur.[11,12] This is achieved by implanting an electrode around one phrenic nerve; the frequency of discharge is regulated by a radiofrequency transmitter. One phrenic nerve is stimulated but contralateral ventilation often occurs, possibly due to mediastinal shift; if this is inadequate bilateral pacing is possible.[12] Tracheostomy may still be required in these patients if the neuromuscular function of larynx and extrathoracic airway is impaired. Phrenic pacing is not recommended before 3 to 6 months because recovery may still be expected in this period.

Neuromuscular dysfunction

Damage to cranial nerve nuclei or to the nerves themselves may lead to further respiratory sequelae. Upper airway dysfunction may allow pulmonary aspiration to occur if the lungs are not protected, and it is the practice in this unit to leave patients with a nasotracheal tube for the first 24 hours postoperatively if there is any doubt as to the integrity of bulbar function. Frequently bulbar reflexes return once oedema has subsided; if they do not, however, tracheostomy may be required. Maintenance of a patent upper airway during inspiration depends on coordinated contraction of muscles of the tongue, particularly geniohyoid and genioglossus,[13,14] and the pharynx. These muscles prevent the extrathoracic airway from collapse when subatmospheric pressures are generated during inspiration. Vocal cord mobility is also important and interference with the innervation of the intrinsic muscles of the larynx may lead to unopposed adduction of the vocal cords.

Obstructive sleep apnoea has been reported in association with posterior fossa disease, together with the suggestion that this condition may be underdiagnosed in these patients.[15] We were unable to find any similar report of upper airway obstruction occurring 24 hours postoperatively in an awake, cooperative patient after posterior fossa surgery in the absence of macroglossia. Certainly we considered that our patient was at risk from respiratory complications in the postoperative period. The presence of pre-existing bulbar weakness, use of the sitting position and further surgery predisposed to this; furthermore, the operation was characterised by cardiovascular lability which in our experience, and that of others,[6] tends to augur badly for the early postoperative period. The interaction of several different mechanisms may be responsible for the respiratory effects seen in this patient. Complete upper airway obstruction after extubation was most likely due to collapse of the extrathoracic airway secondary to impaired function of the lower cranial nerves, in particular the hypoglossal nerve. Our inability to relieve this obstruction with an oropharyngeal airway could have been because of more distal collapse, in the face of vigorous inspiratory efforts, or because further obstruction at glottic level occurred. Paralysed cords lying in a neutral position, as seen at laryngoscopy, are adducted by high negative intrathoracic pressures and any oedema would tend to exacerbate this effect. Central vagal damage may also have been responsible for the cardiovascular effects seen and gastric stasis in the postoperative period. This case demonstrates the extent of respiratory disturbance which is possible after posterior fossa surgery. In particular, the upper airway obstruction reported here may be part of a spectrum that includes obstructive sleep apnoea, a matter which has received little attention previously in this group of patients.

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Anaesthesia, 1990, Volume 45, pages 225–226

CASE REPORT

Intra-operative pulmonary embolism

Detection by pulse oximetry

S. MICHAEL, R. B. FRASER AND C. S. REILLY

Summary

A case is presented of a 49-year-old patient who had a pulmonary embolism during ovarian cystectomy. The only evidence of its occurrence was a sudden, marked reduction in arterial oxygen saturation as detected by a pulse oximeter. The diagnosis was confirmed 24 hours later by a chest radiograph and a ventilation perfusion scan. Anticoagulant treatment was instituted.

Key words

Complications; pulmonary embolism.
Monitoring; pulse oximetry.

Pulse oximetry has been recommended for monitoring in every area where anaesthesia is administered.[1,2] Its ability to provide an early warning of hypoxaemia has made its adoption almost universal over the past few years. We present a case of intra-operative pulmonary embolism detected by pulse oximetry alone.

Case history

A 49-year-old female patient was admitted to hospital to undergo elective laparotomy for a pelvic mass. She had presented to the gynaecology clinic one month previously with a 3-month history of heavy periods. On examination, she had a pelvic mass which was thought, on ultrasonography, to be a cystic, left-sided ovarian mass.

The patient had received general anaesthesia twice in the past; at the age of 34 years for sterilisation and at 41 years for the incision and drainage of a breast abscess. Anaesthesia and surgery were uneventful on both occasions. No other significant past medical history was noted. She was on no regular medication, was not allergic to any drugs and smoked 10 cigarettes a day.

Examination revealed a healthy, overweight woman with a heart rate of 72 beats/minute, arterial blood pressure of 140/80 mmHg and no abnormal findings on chest auscultation. Full blood count and urea and electrolytes were within normal limits.

The patient was given intramuscular papaveretum 10 mg and prochlorperazine 12.5 mg and subcutaneous calcium heparin 5000 IU one hour before surgery. On arrival in the anaesthetic room an intravenous infusion of compound sodium lactate solution was started through an 18-G cannula inserted in the left forearm, and anaesthesia was induced with fentanyl 150 μg, thiopentone 250 mg and vecuronium 8 mg. The patient's trachea was intubated with an 8-mm cuffed orotracheal tube and anaesthesia was maintained with nitrous oxide 66% and isoflurane (0.5–1%) in oxygen. The patient's lungs were ventilated using a Manley ventilator. Monitoring consisted of continuous electrocardiogram, pulse oximetry, automatic noninvasive blood pressure at 3-minute intervals, inspired oxygen concentration and ventilator alarms.

Thirty minutes after induction of anaesthesia and after a large cystic ovarian mass had been mobilised and the pedicle crossclamped by the surgeon, the pulse oximeter showed a sudden, marked decrease in oxygen saturation, from 97% to 88%. A check of the gas supply, anaesthetic machine, the breathing system and tracheal tube as well as auscultation of the patient's chest showed no abnormalities. No change in heart rate, ECG or blood pressure occurred during this period. It was decided, in view of the patient's smoking habits, that this sudden desaturation was the result of atelectasis. Her lungs were therefore manually hyperinflated with 50% oxygen with a resultant increase in oxygen saturation to 94% which continued until the end of surgery. Residual neuromuscular blockade was reversed with neostigmine 2.5 mg, preceded by atropine 1.2 mg, and upon return of spontaneous ventilation the patient was extubated. She was given 30% oxygen via a facemask, and an oxygen saturation above 94% was maintained. A chest radiograph taken in the recovery ward revealed no abnormality and since the patient remained stable it was decided

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to discharge her to the ward with oxygen therapy for 24 hours.

The patient remained well overnight but the next morning, after removal of the oxygen mask, she appeared cyanosed and arterial blood gas analysis showed a $P\text{O}_2$ of 8.1 kPa. A repeat chest radiograph showed a right lower lobar collapse and a ventilation perfusion scan showed a mismatch in the right midzone. Pulmonary embolism was diagnosed and the patient was anticoagulated initially with intravenous heparin followed by oral warfarin. She ran an otherwise uneventful postoperative course, was discharged on the 8th postoperative day and remained well on routine follow-up.

Discussion

Pulmonary embolism is a serious and potentially fatal complication of surgery. It is commoner after major abdominal, pelvic and orthopaedic surgery. Other risk factors include the contraceptive pill, smoking and neoplasia. Without prophylaxis fatal pulmonary embolism has an incidence of 1%.[3] In the United States pulmonary embolism causes 30 000 deaths annually.[4]

The emphasis is on prophylaxis, but early diagnosis and treatment can reduce the number of deaths. The clinical manifestations of pulmonary embolism are nonspecific, so a high index of suspicion and accurate laboratory tests are required for diagnosis. However, nonspecific investigations, such as chest radiography, electrocardiography and arterial blood gas estimation can help the diagnosis.[5] Our patient showed no other signs or symptoms in the immediate postoperative period and did not become overtly hypoxic until 24 hours after surgery. However, she did require oxygen therapy during this period. A high index of suspicion was aroused by the peroperative events, and therefore the patient was investigated thoroughly; this resulted in prompt and effective treatment. The sudden, peroperative desaturation experienced by our patient could be attributed to no demonstrable cause but the occurrence of a pulmonary embolism.

The peroperative detection of pulmonary embolism by pulse oximetry is not reported widely. In a case of amniotic fluid embolism[6] the first sign of its occurrence was a marked desaturation (to 71%) during Caesarean section under epidural anaesthesia. The patient felt comfortable and complained of no symptoms.

The embolism in our patient probably resulted from a thrombus in a pelvic vein from compression by the ovarian mass. Mobilisation of the mass released the thrombus. It is unlikely that the embolism originated within the mass, since the pedicle had been crossclamped earlier. In relation to the risk factors mentioned above our patient was a smoker and was undergoing pelvic surgery. Histology of the ovarian mass showed a benign lesion. She had received pre-operative subcutaneous heparin which has been shown to reduce the incidence of thrombo-embolism.[7]

Pulse oximetry is a simple, reliable method of monitoring oxygenation continuously.[8,9] Hypoxaemia is the common, nonspecific denominator of a multitude of clinical problems, but its early detection by pulse oximetry alerts the anaesthetist and leads to prompt diagnosis and treatment before serious sequelae have resulted.

The use of pulse oximetry in the patient described in this report resulted in the early diagnosis and treatment of a potentially fatal complication of surgery. The occurrence of a pulmonary embolism must be considered as a cause of any sudden decrease in oxygen saturation during surgery.

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CASE REPORT

Laryngeal mask airway for Caesarean section

S. McCLUNE, M. REGAN AND J. MOORE

Summary

The use of a laryngeal mask airway is described in a patient for emergency Caesarean section, when tracheal intubation was not possible. Provision of the laryngeal mask airway for use in the Maternity Unit is discussed.

Key words

Complications; airway.
Equipment; laryngeal mask airway.

The laryngeal mask has proved to be an effective means of securing the airway in cases of difficult tracheal intubation,[1,2] but its use in obstetric anaesthesia has not been described. A major concern is that the mask does not provide an air-tight seal, and that pulmonary aspiration may occur.

Case history

A healthy 34-year-old 65 kg primigravida at term, with a previously uneventful anaesthetic history, required urgent Caesarean section in early labour, because of sustained fetal bradycardia. Difficulty in tracheal intubation was not anticipated, apart from slight elongation of the mandible.

Routine antacid therapy had been administered, and intravenous fluids were in progress. After transfer to the operating table, with a left lateral tilt, the mother's lungs were pre-oxygenated with 100% oxygen for 5 minutes and monitoring of electrocardiogram, noninvasive arterial blood pressure and peripheral oxygen saturation ($Sa\text{O}_2$) via a finger probe was started.

Thiopentone 325 mg and suxamethonium 100 mg were injected in a rapid sequential intravenous technique, whilst cricoid pressure was applied by an experienced assistant. Laryngoscopy was performed when fasciculations had ceased. The superior aspect of the epiglottis and the posterior wall of the oesophagus were identified, but the larynx could not be visualised, even with transient release of cricoid pressure. Oral intubation with an 8.0-mm Portex cuffed tracheal tube and introducer was unsuccessful. A second intubation attempt also failed, this time using a gum elastic bougie and threading a 7.0-mm cuffed tracheal tube over it. Cricoid pressure was maintained, and the lungs manually ventilated with 100% O_2 and 1% isoflurane after each attempt. Despite this, $Sa\text{O}_2$ continued to deteriorate to 60% and then 36%. Atropine 0.6 mg was given to correct sinus bradycardia.

Skilled anaesthetic assistance was obtained within minutes. A laryngeal mask airway, size 4, was available and easily inserted without an introducer or laryngoscope, and the cuff inflated with 30 ml of air. Manual ventilation with the above gas mixture rapidly restored $Sa\text{O}_2$ to 97%. A small leak from the distal end of the mask was audible. However, cricoid pressure was maintained. On auscultation, air entry was good in both lung fields.

Spontaneous ventilation returned some minutes later. Further neuromuscular blocking agents were not administered. The laryngeal mask was tolerated well by the patient, and anaesthesia continued with 50% O_2 in N_2O and 1% isoflurane. Intravenous midazolam 2.5 mg and cyclizine 50 mg/morphine 10 mg were given incrementally after delivery of the baby. A slow intravenous infusion of syntocinon was started after an initial intravenous bolus of 10 IU.

Maternal arterial blood pressure and heart rate remained stable after insertion of the laryngeal mask and $Sa\text{O}_2$ was constant at 98% with an inspired O_2 concentration of 35–50%. The operation lasted approximately 25 minutes. Surgical access was not a problem, nor was blood loss above average. The duration of maternal hypoxaemia was difficult to determine but was estimated to be 10 minutes. One hundred ml 20% mannitol was infused slowly in case of subsequent cerebral oedema.

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The baby, whose Apgar scores were 3 at 1 minute and 8 at 5 minutes, was not unduly cyanosed at delivery. A bradycardia of 50–60 beats/minute responded well to manual ventilation with 100% O_2, via a tracheal tube. Minutes later, extubation was possible, without any sequelae.

The laryngeal mask was removed shortly after the operation, with the patient in the left lateral position, when she began to cough and open her eyes. She was fully alert and orientated several minutes later, cardiovascular observations remained stable and lung fields were clear on auscultation.

The patient was questioned after operation and the following day. She complained of a sore throat, but did not have any recall of events from the time of induction of anaesthesia until arrival in the recovery room.

Discussion

The laryngeal mask proved to be life saving in this case. After unsuccessful intubation, normal ventilation via a facemask and oropharyngeal airway was ineffective, so further intervention was necessary. Insertion of a nasopharyngeal airway was considered but could have precipitated bleeding into the nasopharynx. Oxygenation rapidly improved once the size 4 laryngeal mask was in place. A size 3 might have provided a more airtight seal in the hypopharynx.

The laryngeal mask is not recommended for use in anaesthetised patients with potentially full stomachs. No effort was made in the above situation to aspirate gastric contents, in case regurgitation resulted. Brain[2] has described the successful insertion of a nasogastric tube through the dorsal channel of the mask without deflating the cuff. Further neuromuscular blocking agents were not required to facilitate surgical access, after the initial dose of suxamethonium. The latter would have made artificial ventilation mandatory, and increased the risk of pulmonary aspiration.

Tunstall and Sheikh[3] commented that the place of the laryngeal mask is yet to be evaluated in obstetric anaesthesia. Normal ventilation with 100% oxygen in the above case was much more effective via the laryngeal mask than with a standard facemask and oropharyngeal airway. Only one insertion was required to place the device correctly and neither laryngoscope nor introducer was necessary. It might have been possible to pass a cuffed tracheal tube through the laryngeal mask, as described by Brain.[2] Eight of the 18 maternal deaths directly attributable to anaesthesia (1982–1984)[4] were due to difficult intubation. Therefore, the laryngeal mask should perhaps be an essential item in the delivery suite, to deal with this particular problem.

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Anaesthesia, 1990, Volume 45, pages 229–231

CASE REPORT

Contralateral tension pneumothorax during thoracotomy for lung resection

D. A. GABBOTT AND J. A. CARTER

Summary

A patient underwent right thoracotomy and upper lobectomy for a mass found on routine chest radiography. He became profoundly cyanosed with a bradycardia and severe reduction in oxygen saturation at completion of surgery. The diagnosis of tension pneumothorax on the contralateral side to surgery was made and treatment instituted. The causes, treatment and implications of such an event during general anaesthesia for lung resection are discussed.

Key words

Anaesthesia; thoracic.
Complications; pneumothorax.

Pneumothorax in unanaesthetised patients usually presents as dyspnoea, with or without chest discomfort. It may occur spontaneously after rupture of congenital bullae, or secondary due to infection, trauma, malignancy, acute or chronic airways disease, or be the result of iatrogenic causes. The development of tension within the pleural cavity rapidly transforms the condition into an acute medical emergency and prompt diagnosis and treatment are essential. The presenting signs of a tension pneumothorax under anaesthesia are decreased oxygen saturation, increased difficulty in ventilation of the lungs, and circulatory collapse that results from mediastinal shift and compression of the great veins and opposite lung. These signs may not be apparent if the other side of the chest is open during thoracotomy, because mediastinal shift may not compress or distort these structures so much as when the chest is closed.

Air in the pleural cavity and lung collapse are obvious consequences of thoracotomy, and chest drains are routinely inserted into the pleural space of the operative side at the end of the operation. Poor respiratory function immediately after operation is often ascribed to failure of collapsed lung to re-expand, or to blockage of these drains. We describe here a case of tension pneumothorax that occurred during thoracotomy for lung resection, on the contralateral side to surgery, which only became apparent after closure of the chest.

Case history

A 74-year-old man with a history of cough and haemoptysis was found to have a mass in his right upper zone on chest radiography. This was inaccessible to bronchoscopy and he was scheduled to have an exploratory thoracotomy and partial lung resection. His past medical history included an inferior myocardial infarction 2 years previously, complicated by cardiogenic shock that required inotropic support. He had made a good recovery from this, and had no other history of chest disease.

Anaesthesia was induced with etomidate 20 mg, supplemented by fentanyl 250 μg, and maintained with nitrous oxide and isoflurane. Suxamethonium 100 mg was given to facilitate passage of a large left-sided Robertshaw bronchial tube, after which muscle relaxation was maintained with intermittent boluses of vecuronium. The patient was placed in the left lateral decubitus position and a thoracic epidural inserted, easily and atraumatically, by a right lateral approach, immediately before surgery was started.

Ventilation of the lungs was achieved using a Nuffield Penlon 200 series ventilator driving a Bain system and there was, therefore, no immediate method available to measure inflation pressure during manual ventilation. End-tidal carbon dioxide and oxygen saturation were measured continuously using a Nelcor N-1000 multifunction analyser and fresh gas flows adjusted to maintain an end-tidal CO_2 of 4.7 kPa. The oxygen saturation decreased to 82% during one-lung anaesthesia and 1.0 kPa of positive end expiratory pressure was added; the gas flows were changed from 50% oxygen to 98% oxygen with 2% isoflurane, and oxygen was insufflated into the upper lung.

There was little improvement in oxygen saturation, despite this, until right upper lobectomy had been completed and two-lung anaesthesia was resumed, when the Sao_2 rose to 94%. Some difficulty was encountered re-

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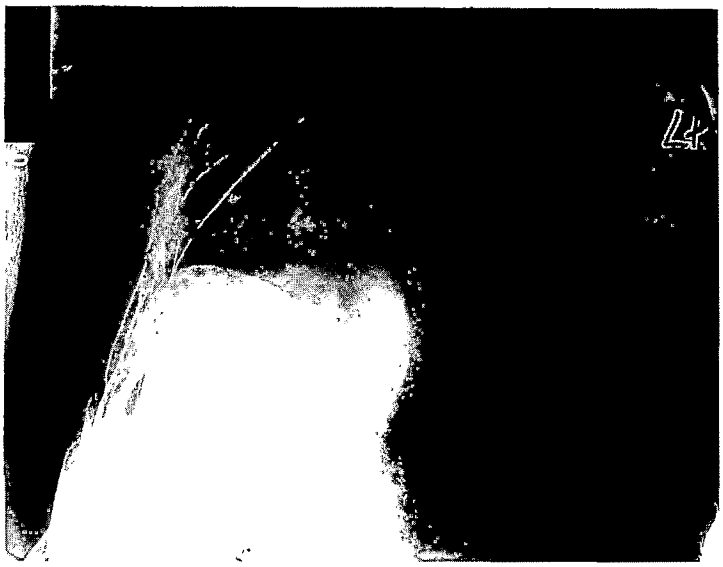

Fig. 1. Chest radiograph at end of operation showing left-sided tension pneumothorax.

expanding the right middle lobe because of a twisted bronchus, and manual positive airway pressure was applied to both lungs at this stage.

It was noted, as the chest cavity was being closed, that the right lung was coming out through the chest wall incision with inspiration. Apical and basal chest drains were inserted into the right chest cavity and after reversal of residual paralysis with glycopyrronium and neostigmine the patient started to breathe spontaneously, but his saturation decreased to 80% and at this stage he was coughing on the bronchial tube. This was therefore removed, but breathing rapidly became laboured and saturation decreased further to 65%. He was turned onto his back and re-intubated with a cuffed tracheal tube and it was noted that the left side of his chest was hyperinflated and moving less than the right. Both right-sided chest drains were bubbling and swinging. The trachea was deviated to the right, and air entry was decreased over the left side of his chest, which was also hyper-resonant. An emergency chest radiograph was performed (Fig. 1) and as the patient's condition continued to deteriorate, a 14-gauge cannula was inserted through the left chest wall. There was a hiss of escaping air and immediate improvement in the patient's condition. A chest drain was then inserted into the left thoracic cavity and oxygen saturation improved to 100% on an F_{IO_2} of 1.0. The patient made an uneventful postoperative recovery, and the left-sided chest drain was removed 5 days later. Histological examination of the tumour revealed a small cell carcinoma.

Discussion

Contralateral tension pneumothorax after lung resection is a rare phenomenon, although simple pneumothorax that occurs during positive pressure ventilation is well described.[1] Contralateral pneumothorax is, however, common in neonatal diaphragmatic hernia[2] when high inspiratory pressures are used to attempt to inflate the hypoplastic lung on the side of the hernia. It has been shown experimentally in lambs that the pressure necessary to expand the more hypoplastic areas of lung exceeds the pressure required to rupture normal lung.[3] This is expressed in the Laplace equation because the pressure necessary to expand a small airway is greater than that required for a large one. For this reason, in order to expand collapsed lung at the end of a thoracotomy, it is usual to ventilate the lungs manually to a higher pressure than is used for normal ventilation (up to 5.3 kPa). This should be performed with observation of both the generated pressure and the expansion of the lung. Unfortunately, in this case, because the usual ventilator was out of service, the pressure generated was not readily measurable. It would, therefore, seem likely that the cause of the pneumothorax was barotrauma caused by attempts at re-expanding the collapsed right middle lobe.

The rapid deterioration in the patient's condition after reversal of muscle relaxation may have been the result of coughing on the bronchial tube. This creates very high intrapulmonary pressures and is suggested to be the main cause of positive pressure within a tension pneumothorax in the spontaneously breathing patient.[4]

Other causes of pneumothorax relevant to thoracic surgery include damage to the contralateral pleura during surgery, puncture of the pleura during insertion of a central venous cannula or thoracic epidural needle; or damage to the bronchus by the use of an introducer in the bronchial tube. We are satisfied that none of these other causes was relevant to this case.

Tension pneumothorax is a medical emergency, and once diagnosed or suspected, a large bore intravenous cannula should be inserted through the chest wall, preferably in the second intercostal space in the midclavicular line. There may not be time to wait for a chest radiograph, or for the more formal procedure of insertion of a chest drain. We propose that particular care should always be taken when testing bronchial stumps or inflating collapsed lung after lung resections, and a high index of suspicion maintained about pneumothorax if there is any postoperative respiratory embarrassment.

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APPARATUS

The effect of exhaled alcohol on the performance of the Datex Capnomac

M. A. FOLEY, P. R. WOOD, W. J. PEEL, G. M. JONES AND P. G. LAWLER

Summary

We investigated the response of the Datex Capnomac to alcohol in expired air. The greatest response was seen when the Capnomac was set to monitor halothane. There was an approximately linear correlation with blood alcohol levels. This effect is of sufficient magnitude to introduce inaccuracies in the measured concentration of halothane.

Key words

Anaesthesia; volatile, ethyl alcohol.
Monitoring; anaesthetic vapour.

The Datex Capnomac (Datex Instrumentation Corporation, Helsinki) is an infrared absorption spectrophotometer which combines capnography with measurement of the inspired and expired concentrations of the volatile anaesthetic agents halothane, enflurane and isoflurane. The manufacturers are aware that the machine also responds to ethyl alcohol but do not offer a quantitative assessment of this interaction (manufacturer's instruction manual).

We suspected that in patients who have anaesthesia for emergency surgery who had been drinking alcohol there might be significant interference with the measurement of the anaesthetic vapour concentrations. We therefore measured blood alcohol levels in healthy volunteers who had been drinking alcohol. Concurrently we recorded the effect of their expired breath upon two Capnomac machines set to measure volatile anaesthetic vapour concentrations.

Method

Three healthy male volunteers each consumed between 3.6 and 4.4 litres of beer over a 3-hour period, after a 4-hour fast.

A heparinised venous cannula was inserted into a forearm vein of each subject to permit blood sampling. Blood samples were taken before the start of the experiment and at 30-minute intervals thereafter. Five ml of blood was withdrawn and discarded before sampling. A further 5 ml was then removed and retained for measurement of alcohol levels. The samples were stored overnight at 4°C and assayed the next morning by gas chromatography.

Each subject breathed through a mouthpiece into two Capnomac analysers in succession, immediately before sampling. Both machines had been serviced by the manufacturers 2 days previously and each was allowed to warm up for 2 hours before making any measurements. The mouthpiece had not been previously exposed to volatile anaesthetic agents and between sampling was cleaned with 0.1% chlorhexidine in water. Iso-propyl alcohol was avoided since it is known to produce factitious readings of anaesthetic concentration on an apparently identical monitor (Puriton Bennett, PB 254).[1]

Each subject breathed into each instrument for one minute before recording a stable display. No alcohol was consumed for 10 minutes before each recording. Recordings were made with the machines set to measure halothane, enflurane and isoflurane in turn.

The Capnomac measures vapour concentrations to one decimal place. An intermediate concentration was recorded, if the display alternated between two consecutive figures. For example, alternation between 0.4 and 0.5% was recorded as 0.45%. The volunteers were escorted home at the end of the experiment.

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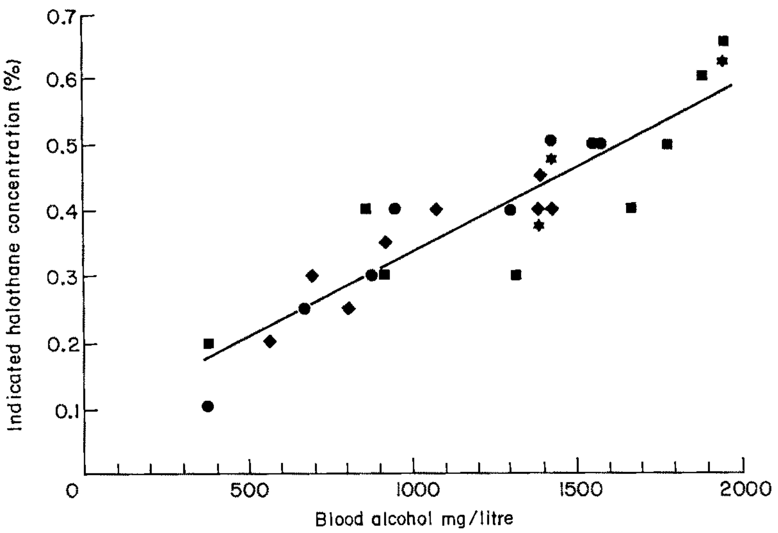

Fig. 1. Halothane concentration (%) against blood alcohol concentration using Capnomac 1. ■, subject 1; ●, subject 2; ◆, subject 3; ✱, blood alcohol concentration in each subject at end of experiment.

Results

All three channels on the Capnomac monitors responded to ethyl alcohol. The sensitivity was greatest when the machines were set to monitor halothane (Figs 1 and 2). Each machine responded in an approximately linear fashion. Capnomac 1 displayed a halothane concentration of 0.65% at the highest measured blood alcohol concentration. Both machines, when set to detect enflurane and isoflurane, registered a small response with alcohol but never higher than 0.1% vapour concentration across our range of blood alcohol levels.

Discussion

Ethyl alcohol in expired air caused the Capnomac to register a vapour concentration as though it were responding to halothane. There was a direct correlation with blood alcohol level, but the Capnomac response varied between instruments.

Our results indicate that the effect could be significant. One Capnomac registered the equivalent of 0.65% halothane i.e. nearly one MAC halothane in expired air, after one subject had consumed 4.4 litres of beer (blood alcohol concentration 1950 mg/litre).

A patient who had just consumed a large amount of alcohol would only be anaesthetised for a life-threatening emergency. However, patients may be anaesthetised the morning after they consumed a large intake of alcohol and it is known that at this time the blood alcohol concentration can exceed the legal limit for driving. Figure 1 shows that blood alcohol levels at the legal limit for driving are detectable by this Capnomac and register as a halothane concentration of 0.25%.

Capnomac 2 in our study demonstrated a greater scatter around the regression line than did Capnomac 1. This

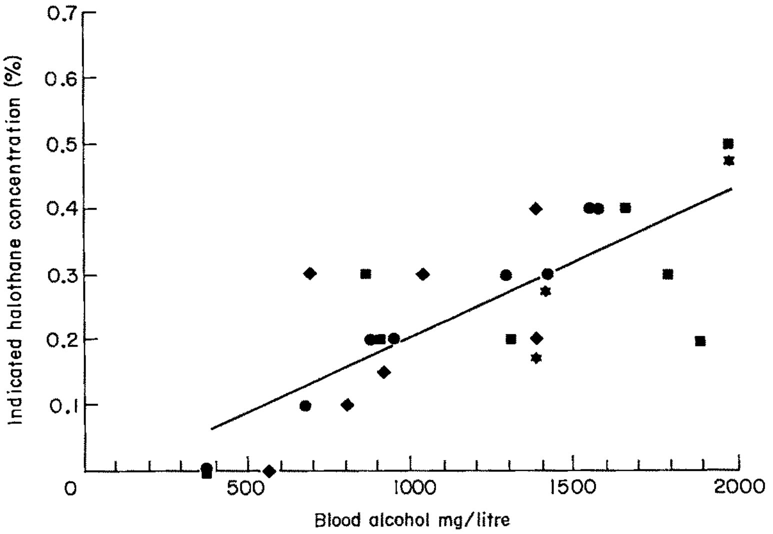

Fig. 2. Halothane concentration (%) against blood alcohol concentration using Capnomac 2. ■, subject 1; ●, subject 2; ◆, subject 3; ✱, blood alcohol concentration in each subject at end of experiment.

might be partly explained by the lack of sensitivity of the instrument, which only records to the nearest 0.1%. Oral retention of alcohol might also contribute to the scatter. Residual oral alcohol is detectable up to 15 minutes after the cessation of drinking.[2] Time constraints in our experiment meant that we restricted the period of nondrinking before analysis to 10 minutes.

Blood and breath levels continue to increase and peak at about 2 hours after the consumption of alcohol.[2,3] Potential inaccuracies in our method could have been reduced if the measurements had been performed after completion of drinking. However, this was not done because volunteer compliance might then have been a problem. The final blood and expired air samples were taken 40 minutes after completion of drinking (indicated in Figures).

We consider our findings to have practical importance, despite the experimental limitations. We realise that anaesthetists who use the Capnomac monitor may be aware of some interference from alcohol in exhaled breath, but the extent of this effect may not be widely appreciated. It is interesting, however, that the police scientific services are well aware of the false positive effects of anaesthetic agents, glues and petrol on their laboratory alcohol analysers (P.G.L. personal communication). A similar monitor (Puritan Bennett, PB 222) was also responsible for detecting nitrous oxide contaminated with hydrocarbon impurities.[4]

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Anaesthesia, 1990, Volume 45, pages 235–236

APPARATUS

An epidural injection simulator

A. P. DAYKIN AND R. J. BACON

Summary

The construction and function of a teaching aid for the insertion of epidural injections is described.

Key words

Equipment.
Education.

A degree of expertise is required to perform an epidural injection safely that takes time and practice to perfect. One of the most common potentially serious complications of this procedure is puncture of the dura mater, which has an incidence of between 0.2% and 20% depending on the experience of the operator.[1] The consequences of this complication may not be significant in the majority of patients, but include headache in up to 75% of patients and rarely persistent neurological disturbances.[2] The pattern of the second stage of labour may be considerably changed by inadvertent dural puncture and require instrumental delivery.

The teaching of this technique usually involves women in labour, or anaesthetised patients who have routine surgery. The former group are often technically easier, but teaching such a procedure on an awake and often distressed patient is stressful for trainee, trainer and patient alike. The use of models for teaching is advocated.[3] Most of these include fruit of various kinds, but commercially available models are also produced.

We have designed and constructed a teaching aid in order to demonstrate technique 'feel' and common errors, on which trainees may practise before their first attempts on patients. We hope that the device will help to reduce the high dural puncture rate in inexperienced hands.

Apparatus

The device (Fig. 1) contains three main elements to simulate variable resistance to needle advancement, loss of resistance to injection on entering the epidural space and dural puncture.

The apparatus is represented schematically in Figure 2. It consists of a case into which a modified Tuohy needle (A) is inserted. Resistance to needle advancement is simulated by two spring-loaded friction plates. The first (B) has only a light spring loading and represents the resistance encountered when pushing a needle through supraspinous and interspinous ligaments. The second (C) has an adjustable spring loading that can be set by the trainer to simulate the various resistances that may be encountered in the ligamentum flavum.

The epidural space and dura are represented by two modified plastic vertebrae mounted on a moveable base (E). This can be positioned by the trainer in two planes, to represent an epidural space anywhere in the range 30–60 mm from the skin surface, and 0–25 mm cephalad or caudad from the insertion site.

The needle triggers a solenoid valve (D) to open, as it enters the 'epidural space' (F), and releases the resistance to injection of fluid or air. Any fluid then injected is collected in a second syringe mounted on the casing, out of sight of the trainee. Further advancement of the needle by more than 2 mm activates a buzzer that denotes dural puncture (G,H).

The device may be mounted on a desktop either vertically or horizontally to simulate both the lateral and sitting position. A window above the vertebrae allows the trainer but not the trainee to see the position of the needle.

Discussion

All grades of anaesthetist were asked to use the device during development of the prototype. Our impression was that the more senior grades did not progress to 'dural puncture', and the junior anaesthetists who did, on repeat

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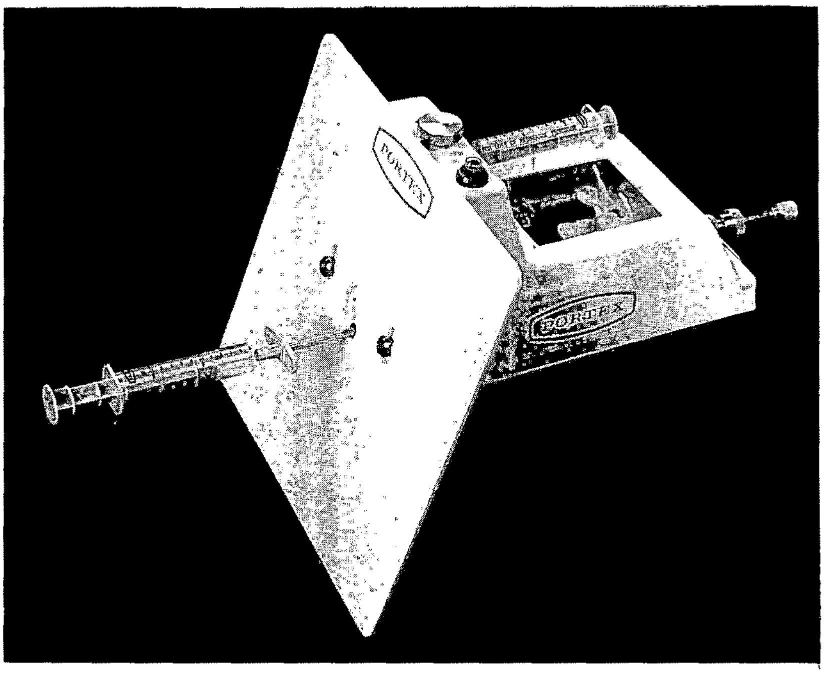

Fig. 1. Photograph of epidural teaching aid.

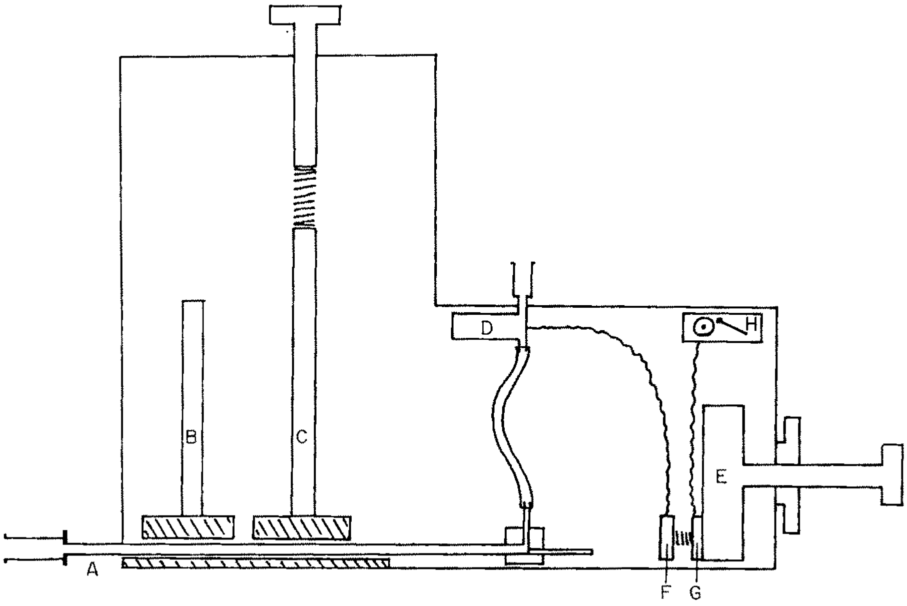

Fig. 2. Diagram of simulator. A, modified Tuohy needle; B, first resistance (light); C, second resistance (variable spring loading); D, solenoid valve; E, moveable back place; F, 'epidural space' contact; G, 'dural tap' contact; H, 'dural tap' alarm.

insertions very quickly became successful. A formal trial will shortly be conducted on anaesthetists with no previous experience of epidural injections.

This teaching aid is for the midline approach only, but if the lateral approach to the epidural space is advocated, it is hoped that after initial training on this device and subsequently on patients, the trainee will then be safer when learning the alternative approach.

Acknowledgments

The authors thank Portex Limited for their assistance with the development of this project. Details of the simulator may be obtained from: Portex Limited, Hythe, Kent CT21 6JL.

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APPARATUS

Minimum airway pressure weaning

Weaning from mechanical ventilation at 50 breaths/minute by reduction of inflation pressure using a pressure generator

P. S. K. TAN, M. K. CHAKRABARTI AND J. G. WHITWAM

Summary

Ten patients, whose lungs were ventilated initially with intermittent positive pressure ventilation at conventional rates after myocardial revascularisation or cardiac valvular surgery, were weaned using a valveless high frequency jet ventilator at a constant rate of 50 breaths/minute. The withdrawal of ventilation was achieved, when clinical criteria permitted, by reduction of the tidal volume preset on the jet ventilator in successive stages; this was effected by stepwise decreases in the jet driving pressure. This new mode of weaning at a constant rate of 50 breaths/minute is associated with minimum peak airway pressures. Synchronisation of the patient's breathing with the valveless ventilator is not required and weaning is tolerated well by the patient. Arterial oxygen tension and saturation were maintained throughout weaning and did not decline after extubation of the trachea.

Key words

Ventilation; high frequency, weaning.

Intermittent mandatory ventilation (IMV) is used widely as a means of decreasing the frequency of mechanical ventilation with provision for the patient to take spontaneous breaths.[1] A disadvantage of IMV is that the start of a breath delivered by the ventilator may coincide with expiration from a spontaneous breath, and cause increased airway pressure which may result in pulmonary barotrauma and distress in lightly sedated patients; synchronized IMV (SIMV) helps to overcome this problem. Another technique for weaning is mandatory minute ventilation (MMV), in which the ventilator delivers the difference between a preset minute volume and the total volume attained by spontaneous ventilation.[2] However, in this mode a patient who breathes at or above the preset minute volume by taking frequent ventilations with a small tidal volume may fail to eliminate carbon dioxide effectively.

Airway pressure is reduced to a minimum if weaning is carried out using small tidal volumes at a frequency of more than 40 breaths/minute and the problem of spontaneous ventilation becomes less important; the need for synchronisation is overcome by using a valveless ventilation system. This study reports the first application in man of weaning from mechanical ventilation at 50 breaths/minute by reduction of inflation pressure using a pressure generator.

Methods

Patients

Observations were made on one female and nine male adult patients in the intensive care unit after elective myocardial revascularisation or cardiac valvular surgery. Ventricular function, assessed by exercise tolerance and cineangiography, was within accepted limits for patients who undergo cardiac surgery (ASA 3 or 4). Their ages and weights were in the ranges 44–82 years and 51–100 kg respectively.

Premedication consisted of lorazepam, papaveretum, hyoscine and droperidol, and anaesthesia was based on a regimen that included thiopentone, fentanyl, midazolam and pancuronium. The trachea was intubated with a standard tracheal tube (8.0–9.0 mm Portex) and ventilation during surgery was carried out using a mixture of nitrous oxide (50–66%) in oxygen.

Intermittent positive pressure ventilation (IPPV) was applied, on transfer to the intensive care unit, using a conventional ventilator (Cape-Waine or Engstrom Erica) at 12 breaths/minute and a tidal volume (V_T) of 10 ml/kg with 50% O_2 in air. Systemic arterial and central venous pressures, electrocardiogram (ECG) and heart rate were displayed in analogue and digital form (Roche Monitor

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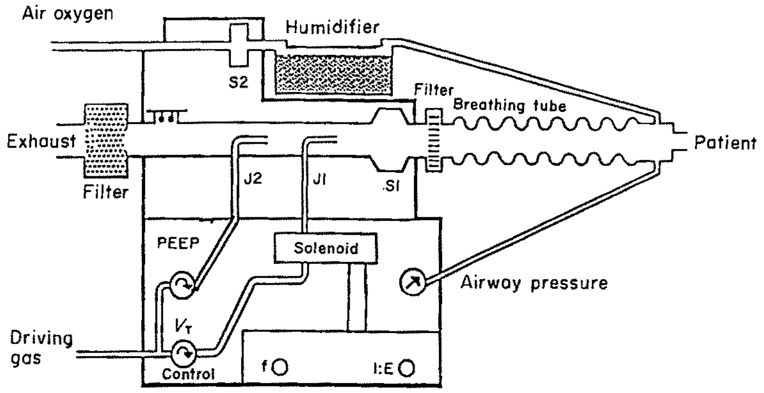

Fig. 1. Jet ventilation system. J1, ventilating jet; J2, positive end-expiratory pressure (PEEP) jet; V_T, tidal volume control; S1, flow sensor for measuring expired volume; S2, flow sensor for measuring fresh gas volume for the expiratory time taken from the jet pulse generator; f, ventilating frequency control; I:E, inspiratory:expiratory ratio control.

120). The airway pressure was recorded continuously with a strain gauge and heated stylus recorder (Devices MX2). Arterial blood gases and the arterial oxygen saturation were measured (Radiometer ABL1).

Patients were transferred to the new ventilator when the following criteria were fulfilled: stable ECG and mean arterial pressure without inotropic support; Pa_{O_2} above 10 kPa, Sa_{O_2} greater than 95% and Pa_{CO_2} between 4.0 and 5.0 kPa; core temperature above 36°C and toe temperature above 35°C; total blood loss via chest drains under 100 ml/hour; alert and responsive to command.

Ventilator

The prototype ventilator which was used is described elsewhere.[3,4] The respiratory fresh gas, supplied via a T-piece at the tracheal tube, is driven into the patient's lungs by an independent source of gas from a jet placed downstream in the breathing system (Fig. 1). The driving pressure in the jet can be adjusted to generate any pressure in the breathing system to a maximum of 6 kPa. The jet driving pressure was set initially at 160 kPa (1.6 bar) to generate a peak pressure in the breathing system of around 1.5 kPa. The ventilatory rate was set at 50 breaths/minute and the fresh gas flow at 200 (ml/kg)/minute with an Fi_{O_2} of 0.5.

The peak airway pressure (P_{aw}) and tidal volume (V_T) were measured. Arterial blood samples were analysed for Pa_{O_2}, Pa_{CO_2}, and Sa_{O_2}, after time for equilibration. The number of spontaneous respirations per minute was counted on two occasions 5 minutes apart, and averaged.

The jet driving pressure was reduced successively by 20% until five stages were completed. The above measurements were repeated at each stage. The patient was assessed clinically for attainment of the normal criteria for extubation. The respiratory rate, Pa_{O_2}, Pa_{CO_2}, and Sa_{O_2} were measured again after extubation (stage 6).

Statistical analysis was applied, where appropriate, using one-way analysis of variance and regression analysis. A 'p' value less than 0.05 was accepted as significant.

Ethics committee approval and informed patient consent were obtained for this study.

Results

Reduction of the driving pressure produced corresponding reductions in peak airway pressure, tidal volume and expired minute volume (Table 1). Mean driving pressure was reduced from 160 kPa in stage 1 to 60 kPa in stage 5. Mean peak airway pressure decreased from a mean (SD) of 1.5 (0.08) kPa in stage 1 to 0.5 (0.03) kPa in stage 5. Regression analysis of the mean peak airway pressure and driving pressure gave the regression equation $y = 9.23x - 0.04$ ($r^2 = 0.994$).

The mean tidal volume decreased from 369 (23) in stage 1 to 151 (10) ml in stage 5. Regression analysis of the mean tidal volume and driving pressure gave the regression equation $y = 215.76x + 18.34$ ($r^2 = 0.995$). The mean minute ventilation volume decreased from 17.5 (1.4) litres in stage 1 to 7.23 (0.5) litres in stage 5.

There was a reduction in Pa_{O_2} from 18.3 (1.7) kPa in stage 1 to 16.6 (0.9) kPa in stage 5, but the difference was not significant ($p < 0.35$; Table 2). The Pa_{O_2} after extubation (stage 6) was 17.3 (1.5) kPa. Arterial oxygen saturation remained more than 97% throughout the stages of weaning, and after extubation.

The Pa_{CO_2} increased from 4.44 (0.21) kPa in stage 1 to 5.79 (0.31) kPa in stage 5 ($p < 0.01$); Pa_{CO_2} after extubation was 5.24 (0.33) kPa. The rate of spontaneous ventilation increased from 0.8 (0.5) breaths/minute in stage 1 to 11.4 (1.1) breaths/minute in stage 5; the rate was 16.6 (0.8) breaths/minute after extubation.

Table 1. Relationship between pressure applied to driving jet (Driving Pressure, DP), peak airway pressure (P_{aw}), tidal volume (V_T) and minute ventilation (V_E). Data shown as mean (SD).

DP (kPa)	P_{aw} (kPa)	V_T (ml)	V_E (litre)
160	1.5 (0.08)	369 (23)	17.4 (1.3)
140	1.2 (0.07)	313 (22)	15.5 (1.1)
110	1.0 (0.07)	260 (16)	12.5 (0.8)
90	0.7 (0.05)	207 (14)	10.3 (0.7)
60	0.5 (0.03)	151 (9)	7.2 (0.4)

Table 2. Relationship between pressure applied to driving jet (Driving Pressure, DP), arterial oxygen partial pressure (Pa_{O_2}), arterial oxygen saturation (Sa_{O_2}), arterial carbon dioxide partial pressure (Pa_{CO_2}) and spontaneous ventilation rate. Data shown as mean (SD).

DP (kPa)	Pa_{O_2} (kPa)	Sa_{O_2} (%)	Pa_{CO_2} (kPa)	*Spontaneous* rate (breaths/minute)
160	18.3 (1.7)	98.2 (0.3)	4.44 (0.21)	0.8 (0.6)
140	19.2 (1.3)	98.5 (0.3)	4.60 (0.13)	1.7 (0.8)
110	19.1 (1.5)	98.3 (0.3)	4.86 (0.21)	2.9 (0.8)
90	17.9 (1.1)	97.9 (0.2)	5.32 (0.27)	5.7 (1.0)
60	16.6 (0.8)	97.5 (0.3)	5.79 (0.31)	11.4 (1.1)
After extubation	17.3 (1.4)	97.2 (0.5)	5.24 (0.34)	16.6 (0.9)

All patients fulfilled the clinical criteria for extubation at the end of stage 5.

Discussion

Weaning from mechanical ventilation is often achieved in cardiac surgical units by nurses using IMV systems. With IMV, the ventilator frequency is reduced progressively to 1–2 breaths/minute while V_T is maintained constant. Synchronisation is required to inhibit a ventilator breath when expiratory flow is generated in the breathing system and the finite delay in sensing expiratory flow makes synchronisation more difficult to achieve at higher rates of spontaneous breathing. The use of a low V_T at 1–2 breaths/minute restricts alveolar ventilation and results in hypercapnia; larger tidal volumes may improve gas exchange, but are associated with detrimental effects of raised airway pressures.

This new method of weaning at minimum airway pressures and a constant rate of 50 ventilator breaths/minute fulfils the basic requirement for weaning from mechanical ventilation. The reduction in driving pressure in five equal stages produced a linear reduction in the peak airway pressure (Fig. 2) and parallel reductions in tidal volume (Fig. 3) and minute ventilation. The five weaning stages were intentionally conducted over about 2.5 hours to permit critical clinical assessment of the patient, who received a minimum safe level of ventilation at all times despite minute to minute fluctuations in his (her) ability to breathe.

The absence of valves in the breathing tube in this ventilator produces a resistance no higher than any open T-piece (Mapleson D) system and allows the patient to breathe spontaneously without fighting or the need for synchronisation. The system was tolerated well by all the patients in this study.

The Pa_{CO_2} increased in an inverse manner to the reduction in tidal volume and minute ventilation (Fig. 4), as weaning progressed. This increase provides the necessary stimulus for spontaneous ventilation to occur and parallel changes were observed in the rate of spontaneous breathing. Minute ventilation volume was maintained at a safe level despite the low tidal volume at stage 5. The increase in Pa_{CO_2} did not exceed normal values and provided an indication of the ability of the patient to respond to this stimulus. Pa_{CO_2} declined slightly after extubation but remained within the normal range. There are two possible causes for this decrease. Firstly, an increase in airway resistance may be expected when a patient breathes through a tracheal tube and this may result in a small degree of CO_2 retention in a patient whose muscle function and ventilatory drive are still recovering after anaesthesia. Secondly, spontaneous ventilation via a tracheal tube is not tolerated easily when the patient is alert and the conscious effort required to suppress gag and cough reflexes may result in some inhibition of spontaneous ventilation. The arterial oxygen saturation (Fig. 5) and tension were maintained well throughout all stages of weaning.

Previous studies have shown that the peak airway pressure during mechanical ventilation is minimal at a ventilator frequency of 50–60 breaths/minute in patients with normal lungs, patients with reduced lung compliance and those with increased airways resistance.[5] Ventilatory frequencies above 100 breaths/minute are associated with

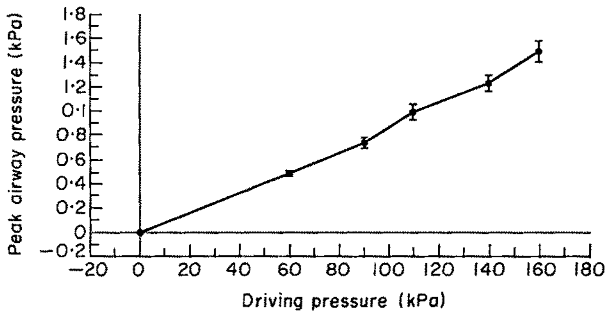

Fig. 2. Pressure applied to driving jet and peak airway pressure. Bars represent SD.

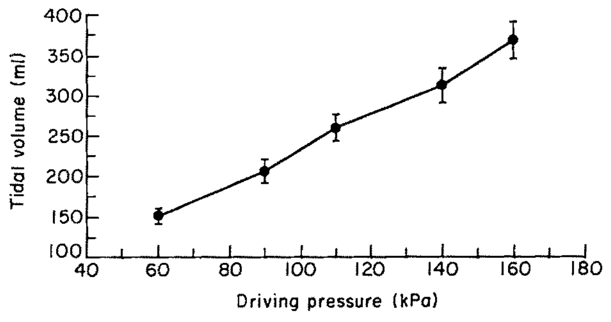

Fig. 3. Pressure applied to driving jet and tidal volume. Bars represent SD.

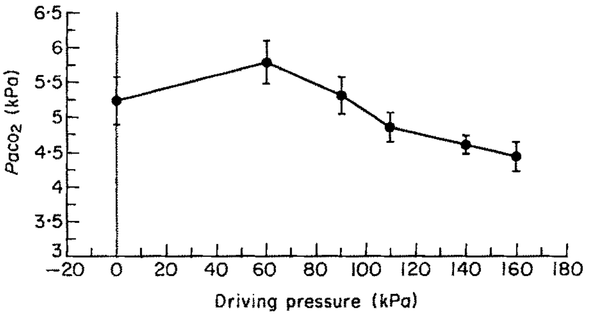

Fig. 4. Changes in arterial carbon dioxide partial pressure ($Paco_2$) during weaning (right to left). Ventilator rate at constant 50 breaths/minute. Bars represent SD. None of the changes reached statistical significance.

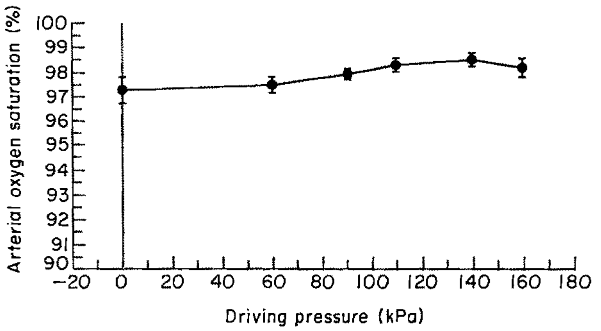

Fig. 5. Arterial oxygen saturation during weaning (right to left). Bars represent SD. None of the changes reached statistical significance.

gas trapping, increases in FRC and peak and end expiratory pressures (generated PEEP), and a decrease in cardiac output. A ventilator rate greater than 50 breaths/minute also reduces the efficacy of end-tidal CO_2 monitoring using a conventional infrared analyser. A ventilator frequency of 50 breaths/minute was chosen for these reasons.

In conclusion, this new mode of minimum airway pressure weaning using a valveless, constant pressure generator at 50 breaths/minute provides a minimum safe level of ventilation and allows spontaneous breathing without the requirement for synchronisation. It is a mode of weaning compatible with care of ventilated patients in intensive care units and can be managed by nursing staff. Also, its ease of application requires no more than simple noninvasive monitoring facilities such as pulse oximetry and end-tidal capnography.

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Anaesthesia, 1990, Volume 45, pages 241–243

Forum

Is crystalloid preloading useful in spinal anaesthesia in the elderly?

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Summary

Sixty ASA grade 1 or 2 patients, aged 60 years or over, scheduled for surgery to the lower abdomen or lower limbs under spinal anaesthesia were allocated randomly to one of three treatment groups. Group A received 16 ml/kg of Ringer's acetate solution immediately before spinal anaesthesia, group B received 8 ml/kg and group C received no volume preload. Heart rate, arterial pressure and anaesthetic level were recorded by an independent observer. The overall incidence of systemic arterial hypotension (defined as a decrease of 25% or more in systolic arterial pressure) was 27%; there were no significant differences among groups. The overall incidence of hypotension was 60%, when temperature sensation was blocked to T_7 *and above (n = 25). The number of patients with hypotension which required treatment increased as block height increased above* T_7*; at a level of* T_4 *or higher, all patients required ephedrine. Crystalloid preloading had no effect on the incidence of hypotension after spinal anaesthesia in fit, elderly patients.*

Key words

Anaesthetic technique; spinal.
Complications; hypotension.

Arterial hypotension during spinal anaesthesia may be associated with significant patient discomfort and even mortality.[1] Crystalloid preloading is recommended in some textbooks[2–4] as a means whereby the incidence or degree of hypotension is reduced, and is common research practice.[5–7] However, it is not a universal recommendation[8,9] since its value has only been tested in an obstetric population.[10] The purpose of this study was to assess the value of volume preload with crystalloid solution in a group of elderly patients.

Method

Ethics committee approval was obtained for this study, and informed consent obtained from each patient. Sixty ASA grade 1 or 2 patients scheduled for elective lower abdominal or lower limb surgery under spinal anaesthesia were entered into the study.

All patients were premedicated with oral diazepam 2 hours before anaesthesia, 5–15 mg, depending on body weight. An electrocardiograph was connected before spinal anaesthesia, and three measurements of systolic and diastolic arterial pressures were made using an oscillotonometer. A large-bore intravenous cannula was inserted. The patient was then assigned randomly to receive 16, 8 or 0 ml/kg Ringer's acetate solution immediately before spinal anaesthesia. The preload was given over 5–10 minutes, using a pressure infusion device if necessary.

One of the authors (A.J.C.), who had no knowledge of the preload used, then performed spinal anaesthesia. Three to four ml plain bupivacaine 0.5% was given through a 26-gauge needle at the L_2–L_3 interspace. Heart rate, systolic and diastolic arterial pressures were measured at 3-minute intervals, and the height of block assessed using an ethyl chloride spray. Increments of intravenous ephedrine 5 mg were administered to restore arterial pressure if systolic arterial pressure decreased by more than 25% of the lowest of the three baseline measurements. Atropine 0.3–0.6 mg was given if heart rate decreased below 50 beats/minute. All measurements were repeated until the height of block was stable over three consecutive observation periods.

The total number of patients in each group who required ephedrine for hypotension was recorded, together with the height of block at which hypotension occurred.

Results

The three groups were similar in respect of age, weight, gender and maximum block height to temperature sensation (Table 1). The incidence of systolic hypotension which required treatment was similar in all three groups (24–32%; Table 2). Table 3 shows the level of block to cold sensation at which hypotension was first recorded in the three groups. This was the same for groups A and C, but two segments lower for group B.

Table 4 shows the number of patients who developed systolic hypotension for the first time at each level of sensory block. The lower level was recorded if the maximum block height was asymmetrical. Overall, 15 of the 25 patients with block to T_7 or higher required treatment for hypotension (60%). Six of 11 such patients in group A required treatment for hypotension (55%), 4 of 6 (67%) in group B, and 5 out of 8 (63%) in group C.

The mean time interval between subarachnoid injection

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Table 1. Details of patients in each group. Data are expressed as median (range).

Male : female	Age (years)	Weight (kg)	Height (m)	Maximum block level to temperature
Group A 11 : 8	69 (60–83)	75 (65–99)	1.69 (1.60–1.87)	T_7 (T_{11}–T_4)
Group B 11 : 10	71 (61–77)	70 (49–110)	1.69 (1.50–1.90)	T_8 (T_{12}–T_5)
Group C 9 : 11	77 (61–90)	66 (40–87)	1.69 (1.54–1.76)	T_8 (T_{12}–T_4)

and the development of maximum height of block is shown in Table 5.

Four of the 16 patients who required ephedrine for hypotension also required atropine to treat bradycardia.

Discussion

Arterial hypotension after spinal anaesthesia is common.[1] It is caused at least in part by a decrease in total peripheral resistance as a result of sympathetic denervation[11,12] and may be accompanied by a decrease in central venous pressure. The routine use of large volumes of crystalloid solution to prevent this phenomenon by expanding vascular volume is recommended by some authorities,[2–4] whilst others suggest a more selective use of fluids (e.g. if significant blood loss is anticipated) or the administration of vasoconstrictors instead.[8,9] The risks of such decreases in arterial pressure are subject to debate. Coronary blood flow decreases but myocardial metabolic demands also fall.[13] However, at least four deaths were reported in which arterial hypotension was considered to be a major contributory factor.[1] Hypotension may also result in nausea and vomiting. A decrease of 25–30% in systolic arterial pressure is believed to warrant treatment,[14,15] and this criterion was used in the present study.

Table 2. Overall incidence (percentage of total) of hypotension in the three groups.

	Group		
	A 16 ml/kg $n=19$	B 8 ml/kg $n=21$	C 0 ml/kg $n=20$
Incidence of hypotension	6 (32%)	5 (24%)	5 (25%)

No significant difference.

Table 3. Block level to temperature sensation at which hypotension first occurred (if block asymmetrical, lower level taken).

	Group		
	A 16 ml/kg	B 8 ml/kg	C 0 ml/kg
Level	T_7	T_9	T_7

Table 4. Number of patients in each group who developed hypotension for the first time at each level of block, in relation to the total number who attained that level.

	Treatment group			
Block level	A 16 ml/kg	B 8 ml/kg	C 0 ml/kg	Total
T_4+over	1/4	0/1	1/1	2/6
T_5	1/5	2/3	1/3	4/11
T_6	3/5	1/6	1/5	5/16
T_7	1/11	1/6	2/8	4/25
T_8	0/16	0/9	0/11	0/36
T_9	0/17	1/13	0/14	1/44
T_{10}	0/18	0/15	0/17	0/50
T_{11}+lower	0/19	0/21	0/20	0/60
Overall incidence of hypotension	6/19	5/21	5/20	16/60

Table 5. Time interval between subarachnoid injection and maximum block height. Data are presented as mean (SD).

	Group			
	A (16 ml/kg) $n=19$	B (8 ml/kg) $n=21$	C (0 ml/kg) $n=20$	Total $n=60$
Time to reach maximum block height, minutes	13.5 (3.2)	12.4 (3.1)	13.9 (4.5)	13.3 (3.6)

Crystalloid solutions, in volumes commonly used before spinal anaesthesia, appear to be one of the least effective expanders of plasma volume.[16] Studies of the use of crystalloids for prophylaxis against hypotension in parturients have shown inconsistent benefits.[10] The explanation for this may be that crystalloid solutions expand predominantly the interstitial as well as the intravascular fluid compartment.[17] Only 17% of an intravenous dose of Ringer's acetate solution remained in the intravascular compartment in one study.[18]

The results of this study suggest that crystalloid preloading, with volumes in common use, is not effective in the reduction of the incidence of hypotension after spinal anaesthesia. The larger volume used (16 ml/kg) represents 1.2 litres for a 75-kg man and few anaesthetists would wish to give more than this volume to elderly patients over a short period of time because of the risks of pulmonary oedema[8,9,19] and postoperative urinary retention.[1,8,9] In this study, overt pulmonary oedema did not occur and the incidence of urinary retention was not assessed. Nineteen of the 31 male patients had urinary catheters inserted as a routine measure after urological surgery.

The incidence of treatable hypotension in all three treatment groups was related to the number of thoracic segments blocked and 60% of patients with a block to T_7 or higher suffered from hypotension. The treatment of hypotension with increments of ephedrine 5 mg (and atropine in the presence of bradycardia) was effective in all cases. It may be appropriate to monitor patients carefully and treat hypotension immediately if it occurs. Alternatively, intravenous ephedrine prophylaxis could be given to those in whom the block height reaches T_7 or higher.

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Pressor responses to tracheal intubation after sublingual captopril

A pilot study

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Summary

The effect of sublingual captopril on the pressor response to intubation was studied in 40 patients. Captopril was used in one of two doses (12.5 mg and 25 mg) 25 minutes before tracheal intubation. Both doses were associated with a significant reduction in the pressor response to intubation ($p < 0.05$) compared to placebo, but no significant difference existed between the two doses. Neither dose controlled changes in heart rate at intubation. Untoward hypotension occurred in the treatment groups. Caution is advised in the peri-operative use of angiotensin-converting enzyme inhibitors.

Key words

Pharmacology; captopril.
Blood pressure; drug effects.

Tracheal intubation is a potent stimulus to hypertension and myocardial ischaemia. Many agents have been assessed for their ability to obtund this response.[1] Angiotensin-converting enzyme (ACE) inhibitors offer potential benefits in the treatment of both hypertension and chronic heart failure[2,3] but there is relatively little information regarding the haemodynamic responses to intubation and anaesthesia in patients who take these drugs. We studied the effects of sublingual captopril on the pressor response to intubation in patients who underwent elective gynaecological surgery.

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Table 1. Pre-induction data. Data are presented as mean (SD).

	Captopril 12.5 mg	Captopril 25 mg	Control
n	12	10	18
Age, years	39.5 (11.1)	33.0 (8.2)	37.4 (10.2)
Weight, kg	66.3 (11.1)	61.5 (6.3)	62.7 (10.9)
Heart rate, beats/minute	81.5 (10.0)	81.3 (9.7)	80.5 (11.3)
Systolic arterial pressure, mmHg	127.3 (15.8)	132.1 (20.8)	120.8 (12.8)
Diastolic arterial pressure, mmHg	76.3 (10.2)	81.3 (9.7)	75.2 (8.2)

No significant differences.

Methods

Forty adult patients (ASA class 1 or 2), scheduled for elective gynaecological surgery, and who required tracheal intubation, were included in the study. Local ethics committee approval was granted and written consent obtained from the patients. Patients with anticipated difficult intubation, hypertension, renal disease, or weight greater than 120% of the ideal for their height were excluded.

All patients received temazepam 20 mg as premedication, about 90 minutes before operation. Indirect arterial blood pressure and electrocardiograph (ECG) monitoring were instituted on arrival in the anaesthetic room, using an automated oscillotonometer (Critikon 845) and an ECG machine. An intravenous cannula was inserted under local anaesthesia. Patients were allocated randomly to receive sublingual captopril 12.5 or 25 mg, or a sublingual placebo after the baseline heart rate and arterial pressure had been recorded. Neither the patient nor the observers were aware of the nature of the preparation. Blood pressure and heart rate measurements were recorded at 5-minute intervals for 25 minutes. Anaesthesia was induced with thiopentone 5 mg/kg over 30 seconds followed by vecuronium 0.1 mg/kg. Measurements of heart rate and blood pressure were recorded 120 seconds after completion of the injection of thiopentone, and tracheal intubation was performed 30 seconds later. The lungs were ventilated manually with nitrous oxide 70% in oxygen, and isoflurane 1%, before tracheal intubation; thereafter, ventilation was controlled to normocapnia. Further recordings of heart rate and arterial pressure were made at one-minute intervals after intubation for the next 5 minutes. Then, surgery was allowed to start. Thereafter, measurements were recorded at 5-minute intervals throughout the operation until after extubation of the trachea. Fentanyl 1 μg/kg was given if needed during surgery to control tachycardia, and Ringer lactate solution was administered to replace intra-operative blood loss. Patients were observed in the postoperative recovery room for 120 minutes, where further measurements were recorded at 15-minute intervals.

Observations were analysed using one-way analysis of variance, and where a significant F statistic was found multiple comparisons were undertaken by the method of least significant difference. The Chi-square test with Yates' correction for continuity was used to compare nonparametric data.

Results

No significant differences existed among the control group (18 patients), patients who received captopril 12.5 mg (12 patients), and those given captopril 25 mg (10 patients) in respect of age, weight, type of operation, or in the pre-induction heart rate or arterial pressure measurements (Table 1).

No significant differences were found among the groups in heart rate or arterial pressure after induction, but before tracheal intubation. The pressor response was not significantly different between the groups at one minute after tracheal intubation. However, at 2 minutes the mean (SEM) increases in systolic arterial pressure were approximately 5 (5) mmHg and 8 (6) mmHg in patients who received captopril 12.5 and 25 mg, compared to 25 (4) mmHg in the control group. This was statistically significant ($p < 0.05$). There were similar differences at 3, 4 and 5 minutes. There was no significant difference between doses of 12.5 mg and 25 mg.

There were no significant differences among groups in diastolic arterial pressure until 3 minutes after tracheal intubation; both doses of captopril resulted in a decrease in diastolic pressure from pre-induction values, and this was maintained at 4 and 5 minutes in patients who had received a dose of 25 mg. However, no significant difference was found between the two doses of captopril.

The only significant difference in heart rate was at 2 and 3 minutes after tracheal intubation, when there was a greater tachycardia in patients who received captopril 25 mg than in those given 12.5 mg; neither treatment group was significantly different from control (Table 2).

The double-blind nature of the study had to be broken on several occasions. There were three incidents of hypo-

Table 2. Mean (SD) changes in arterial pressure and heart rate compared to pre-induction values.

	Time (minutes) after tracheal intubation				
	1	2	3	4	5
Systolic arterial pressure, mmHg					
Captopril	19.7 (20.5)	8.2 (18.7)*	−4.2 (17.1)*	−10.5 (14.6)*	−16.8 (18.3)*
Captopril 12.5 mg	11.9 (13.0)	4.8 (17.5)*	−3.8 (19.6)*	−10.8 (16.6)*	−13.0 (17.0)*
Control	22.4 (17.5)	24.9 (18.0)	9.7 (14.5)	1.1 (9.6)	−1.9 (12.3)
Diastolic arterial pressure, mmHg					
Captopril 25 mg	26.9 (13.2)	10.3 (10.7)	−3.1 (8.7)*	−6.8 (7.7)*	−13.2 (5.9)*
Captopril 12.5 mg	19.1 (15.2)	8.3 (15.0)	−3.4 (13.8)*	−7.8 (11.7)*	−10.9 (11.6)
Control	32.2 (16.1)	14.8 (13.2)	7.3 (9.3)	0.8 (9.1)	−3.3 (7.4)
Heart rate, beats/minute					
Captopril 25 mg	42.0 (18.7)	39.1 (19.0)†	33.5 (20.8)†	28.5 (24.3)	25.8 (27.2)
Captopril 12.5 mg	24.4 (15.2)	18.5 (14.9)†	15.6 (13.5)†	15.9 (14.7)	15.2 (13.1)
Control	32.4 (17.7)	27.5 (14.0)	21.9 (14.7)	17.7 (15.5)	13.3 (14.8)

*$p < 0.05$ compared with control.
†$p < 0.05$ between treatment groups.

tension (defined as a systolic pressure of less than 80 mmHg). The first occurred during a hysterectomy, 70 minutes after administration of captopril 12.5 mg when systolic arterial pressure decreased over 25 minutes to a minimum of 74 mmHg before it recovered over the next 5 minutes to 80 mmHg after administration of 500 ml of Dextran 70. The second occurred also during hysterectomy, 60 minutes after administration of captopril 12.5 mg; systolic pressure decreased over 10 minutes to reach a minimum of 70 mmHg, persisted for 10 minutes, and recovered after infusion of 500 ml Dextran 70. No excessive blood loss was noted in either case. The third case occurred in the recovery area 70 minutes after administration of captopril 25 mg. The patient had undergone laparoscopy. Systolic arterial pressure decreased to 70 mmHg, but responded over 10 minutes to infusion of 500 ml Ringer lactate solution. None of the patients had a tachycardia.

There were two incidents of profound bradycardia (defined as a heart rate of less than 40 beats/minute). One patient who received captopril 25 mg developed a heart rate of 16 beats/minute during insufflation with carbon dioxide at laparoscopy. Blood pressure before the incident was 139/83 mmHg, and immediately afterwards 160/120 mmHg. She responded to intravenous atropine, and made an uneventful recovery. The other patient in the placebo group developed a rate of 30 beats/minute on peritoneal traction during hysterectomy; blood pressure immediately before the incident was 109/57 mmHg and 126/83 mmHg immediately afterwards.

Discussion

It is known that the ACE inhibitor enalapril reduces the blood pressure changes associated with tracheal intubation.[4] However, enalapril is a prodrug which can be administered only by mouth, and it is slow to take effect. Greater flexibility in the route and timing of administration might be provided by sublingual captopril, but we were uncertain about the most appropriate dose. A study in patients who suffered a hypertensive crisis compared sublingual captopril 12.5 mg to 25 mg, and found that the lower dose controlled arterial pressure within 30 minutes in only 66% of patients.[5] The authors suggested a minimum effective dose of 25 mg. However, tracheal intubation represents a different clinical situation and the data from our study suggest that a dose of 25 mg or more is unlikely to be of greater benefit than 12.5 mg in the control of the pressor response. Tachycardia may lead to myocardial ischaemia[6] and the effect of captopril on heart rate at intubation should be noted. Neither dose was beneficial, although the increase in heart rate after captopril 12.5 mg was significantly less than after a dose of 25 mg.

We encountered unexpected hypotension in the routine follow-up of our patients, and this caused us to curtail the study. Previous work with much larger doses of captopril had not revealed unexpected hypotension in an anaesthetic context.[7] However, a study in which captopril 1 mg/kg was administered led to the recommendation that ACE inhibitors may need to be discontinued before operation because of their adverse effects on cerebral blood flow, linked to a low mean arterial pressure.[8] However other studies of sublingual captopril in the context of hypertensive crisis did not reveal untoward hypotension.[9,10]

Our study was designed to address the question of intubation responses, and the patients were followed under routine clinical conditions. Thus, our incidental findings should be interpreted with caution, since no attempt had been made to standardise the type of gynaecological surgery or preloading between the cases; the latter were left to normal clinical practice. Two instances of hypotension occurred after a dose of 12.5 mg group and one after 25 mg. These findings may indicate that acute ACE inhibition can lead to unpredictable haemodynamic consequences, even in procedures with little blood loss. It remains to be seen if this possible disadvantage could be offset by some effect of peri-operative ACE inhibition on the metabolic response to surgery itself.

The incidents of profound bradycardia observed in both the control and treatment groups are probably related to vagotonic stimuli in the presence of a nonvagolytic muscle relaxant, vecuronium.[11]

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Anaphylaxis to muscle relaxants: predictive tests

We were very interested to read the controversial exchange between E.S.K. Assem and M.M. Fisher about the possibility of carrying out predictive tests relative to the risk of anaphylactic reactions to muscle relaxants.[1,2]

The question is all the more important since case histories (as Fisher says) do not enable us to identify high-risk cases, other than those patients with previous reactions. IgE-dependent sensitivity to muscle relaxants is long-lasting, as all authors who re-evaluate skin tests several years after the first reaction have noted. Assem has recently confirmed this.[3-5] Muscle relaxants are thus different from other drugs, including penicillin. This is a basic point, because it justifies theoretically the search for latent sensitisation. The choice of tests must nevertheless satisfy two criteria: excellent specificity, that minimises the risk of false–positive tests in controls, and high sensitivity, that minimises the risk of false–negative tests in sensitised subjects. No *in vitro* test has been evaluated in this way, as far as we know. We agree with Fisher that these tests cannot yet be used predictively, especially since only a few laboratories do them and their sensitivity is not uniform.[6] On the other hand, several studies have shown that the specificity and sensitivity of prick tests with undiluted muscle relaxants is over 95% for suxamethonium, gallamine, alcuronium, pancuronium and vecuronium.[7-9] Atracurium is less specific because it induces histamine release.[9]

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We have emphasised the fact that any predictive examination must evaluate the five muscle relaxants simultaneously because of the frequency of cross-reactions, and that positivity for one of them implies further testing (intradermal and *in vitro* tests) before any of them can be authorised for use. This state of affairs is very rare. We performed 300 examinations before the first case of latent sensitisation to alcuronium was found. The intradermal reaction confirmed general cross-reactivity, and radioimmunoassay and leucocyte histamine release were positive.[10] Anaphylaxis to muscle relaxants is the primary cause of hypotension during induction of general anaesthesia in France.[11]

A growing number of anaesthetists and immunoallergists carry out predictive prick tests with muscle relaxants. The prick is made with a needle through a drop of muscle relaxant on the forearm. A positive control is carried out with histamine: 10 mg/ml. The technique is simple. The diameter of the wheal is measured 15 minutes later. No accidents have taken place to the best of our knowledge in subjects with negative pre-operative prick tests.

A few doubts must be expressed about prevention by the use of pancuronium instead of suxamethonium. The former is not necessarily safer than the latter; the number of cases is possibly linked to the frequency of use. The number of episodes after vecuronium has increased in parallel with its more and more widespread use in the last 2 years.

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Precautions against injection into the spinal artery during coeliac plexus block

Woodham and Hanna (*Anaesthesia* 1989; **44:** 487–9) have most constructively described the accidental development of paraplegia after probable damage to the artery of Adamkiewicz during coeliac plexus block with alcohol for the pain of hepatic metastases.

It is possible to insert a long needle into a small artery or vein, achieve no aspirate of blood but yet the vessel becomes apparent when radiopaque dye is injected. We use coeliac plexus block mainly for pancreatic carcinoma pain and the procedure is performed with similar frequency to that in the authors' practice at King's College Hospital. The sight of unexpected intravascular spread of X ray contrast medium has led us to be aware that injection of alcohol into a spinal vessel could easily occur. This is the routine which we use to avoid this complication.

Our patients are always awake and sedated, if indicated, with fentanyl. Nitrous oxide and oxygen are given for analgesic supplement if necessary at the time of injection. Some authorities[1] describe the use of general anaesthesia as advisable, but my belief is that it is unnecessary and may mask the onset of accidental neurological damage during injection of alcohol. Careful aspiration is made for any bleeding during positioning of the needles under local anaesthesia. The needles are repositioned if it occurs and a pause of at least 10 minutes is made to allow time for clotting. Omnipaque dye is injected under screening so that intravascular or intrathecal injection would be seen. Two to three ml of lignocaine are injected on each side after injection of radiopaque contrast. There is then a pause for a few minutes to check that no deficit has occurred by asking the patient to move the legs. This small volume of local anaesthetic seems to reduce the pain usually felt on alcohol injection, but it does not appear to diminish the neurolytic effect of 20 ml 90% or 70% alcohol on each side.

These precautions are helpful but, as the authors state, it may not be possible to prevent external trauma to the spinal arterial wall causing spasm and consequent paraplegia. Coeliac plexus block carries this definite risk, so I seriously doubt whether it should ever be used in benign conditions. Our published series[2] showed that there is no lasting benefit in the treatment of chronic pancreatitis pain. We have used coeliac plexus block for this condition when other measures have failed, but I am not aware of having helped any patient with chronic pancreatitis by the procedure. The procedure commonly produces, in contrast, substantial pain relief in malignant disease of the pancreas and liver for sometimes up to one year. Careful patient selection to include only those likely to be helped will prevent this serious complication happening to people with a long life expectancy.

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A reply

We thank Dr Bowen Wright for his interesting letter and description of a technique to try to avoid neurological sequelae after coeliac plexus block. We take this opportunity to raise a few points.

We fully agree that it is possible to inject into a small artery or vein from which no blood can be aspirated. It is our experience on these occasions that the radiopaque dye is washed away, and thus rapidly disappears whilst screening.

The use of a 'test dose' during the performance of a coeliac plexus block is useful but we do not think it would have prevented this unfortunate complication. A small dose of lignocaine injected intrathecally will cause obvious neurological signs shortly after its injection. However, intrathecal placement of the needles would presumably be demonstrated on screening with the injection of the radiopaque dye. We are unaware of any reports that 2–3 ml lignocaine injected into a spinal artery rapidly causes reversible neurological signs; indeed, there is some evidence that damage to the artery of Adamkiewicz is followed by delayed neurological signs after a few hours.[1]

Dr Bowen Wright reports that he usually does this procedure without sedation. Our experience in this unit is that patients tolerate the prone position poorly (many of our patients have painfully enlarged livers). It remains our policy to provide adequate sedation throughout the procedure, so that they can tolerate the position and remain immobile during the performance of the block. We inject bupivacaine before the injection of alcohol to reduce the pain that accompanies injection of alcohol onto the coeliac plexus, rather than as a diagnostic procedure.

We strongly agree with Dr Bowen Wright that a coeliac plexus block with alcohol should not be undertaken lightly and should, in the main, be reserved for patients with malignant disease, especially in view of the relatively poor results that are reported in patients with chronic benign disease.[2] All patients who undergo the procedure must understand the gravity of the procedure and give a full informed consent.

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Analgesia for manipulation of knee

We would like to reply to the letter by Suresh and Ravalia about femoral nerve block for manipulation of knee prostheses (*Anaesthesia* 1989; **44:** 933–4).

They described their astonishment at the degree of analgesia that femoral nerve block (FNB) can provide after operation and concluded that this must be because of release of spasm of the quadriceps as a result of discrete block of the femoral nerve alone. This conclusion is not logical. The possibility that analgesia resulted from a 3-in-1 block is discounted on the basis that a volume as small as 10 ml bupivacaine 0.5% also provided analgesia. Contrast studies in this department have shown that in many cases 10 ml is quite adequate to produce an effective 3-in-1 block. Only 5 ml is required for FNB in isolation. Their finding that a volume of 20 ml produced analgesia of greater duration lends strong support to the view that it is indeed triple block that has produced the desired result.

The femoral nerve, obturator nerve and lateral cutaneous nerve of thigh (LCNT) supply the bulk of the thigh and knee so it is hardly surprising (let alone astonishing) that high quality analgesia results from their blockade.

We routinely perform both major knee surgery and subsequent manipulation under combined block of these three nerves with the addition of a sciatic block and use 5–7 ml of either bupivacaine 0.5% or prilocaine 1% for each nerve. This normally produces complete analgesia for 3–36 hours, depending on the agent used. The quality of surgical anaesthesia is excellent. Spinal and epidural anaesthesia are poor second choices, and we suggest that were the authors to try a sciatic block in addition to the 3-in-1 block then they would be even more impressed.

We find it highly significant, however, that failure to block either the LCNT or, especially, the obturator nerve results in significant postoperative discomfort, even in the presence of an effective FNB. Indeed, it is entirely as a result of an appreciable incidence of failure to block the LCNT and the obturator nerve after 3-in-1 block in this age group that we now block these nerves individually.

We suggest that quadriceps spasm in the absence of effective analgesia is simply reflex spasm in response to pain, and is not in itself the cause of pain.

Finally, we were somewhat alarmed to read that the authors employ narcotic premedication and up to 40 mg papaveratum intravenously in an aged population. We suggest that, in addition to the advantages mentioned by the authors and those cited above, the relative safety of a regional technique is a major indication for its use.

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Anaesthesia for fibreoptic bronchoscopy in children

Fibreoptic bronchoscopy is often performed during investigation of stridor in children. The need for general anaesthesia in these patients increases the problems of airway control because of the need to share an already compromised airway with the endoscopist. A simple and safe method is described.

General anaesthesia is induced either by intravenous or inhalational technique. The child breathes spontaneously

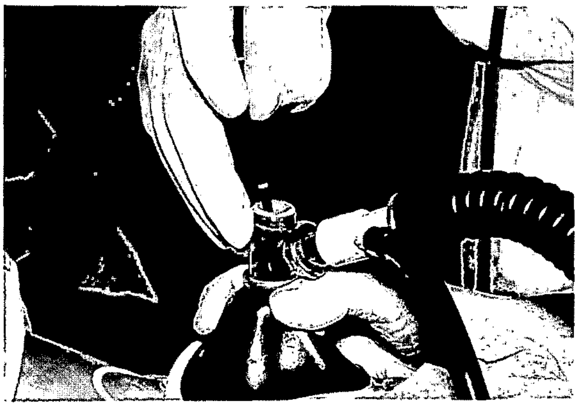

Fig. 1. Fibreoptic bronchoscopy in an anaesthetised child using the Olympus BF 3C10 scope (external diameter 3.6 mm).

via a mask with a high inspired oxygen concentration and halothane and the cords are sprayed with lignocaine. The Bodai suction-safe swivel-Y connector (Sontek Medical Inc. Catalog No: SM1-1002) is a versatile plastic adapter with standard 15 mm fittings which sits well between the Rendell Baker–Soucek mask and the Ayre's T-piece. The bronchoscope can be introduced down the central slit in the diaphragm (Fig. 1). Examination of the upper airways can thus be done with little interference with ventilation. Adequacy of ventilation can be monitored continuously with the pulse oximeter and end-tidal carbon dioxide analyser.

The flexible bronchoscope is solid. Patients must breathe around the scope rather than through it as in the rigid bronchoscope. The Bodai swivel-Y connector can be fitted over the tracheal tube and the examination can be done through the tube. The presence of the tracheal tube, however, reduces the lumen for ventilation and increases impedance to breathing.[1] This method, therefore, has limited use in children, especially infants, since the paediatric bronchoscope has a diameter of 3.5 mm. Various masks with endoscopic side ports have been introduced.[2] Accidental detachment and aspiration of the diaphragm from the endoscopic port may occur.[3] The Bodai swivel-Y has the diaphragm incorporated into the adaptor which reduces this risk. General anaesthesia with spontaneous ventilation with a mask avoids problems of tracheal intubation, such as reduced visibility of the vocal cords as well as postoperative oedema in an already narrowed airway. The small Bodai swivel-Y connector adds little to the apparatus deadspace and allows bronchoscopy to be performed with minimal interference with patient ventilation or the operative field.

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A modified airway to assist fibreoptic orotracheal intubation

Fibreoptic endoscopy-guided intubations for difficult cases have been used in different ways for the last two decades.[1,2] We report our successful experience with a homemade modified airway device that makes fibreoptic endoscopy-aided orotracheal intubations simple and easy.

Twenty adult patients who required general anaesthesia and either had a history of difficult tracheal intubation or were considered to be potentially difficult to intubate, were selected for fibreoptic-aided orotracheal intubation.

Routine monitoring consists of ECG, noninvasive blood pressure and oxygen saturation by pulse oximetry. General anaesthesia is induced and the patient's lungs are ventilated with 100% oxygen through a mask until complete muscle paralysis occurs. An appropriately sized cuffed tracheal tube, well coated with lubricant jelly, is threaded onto the bronchoscope (Pentax SB-15H). The modified Hudson airway No. 4 is inserted and the fibrescope is introduced along its ridge (see Fig. 1) through the length of the airway. This manipulation brings the tip of the fibrescope to the laryngeal opening, close to the vocal cords.

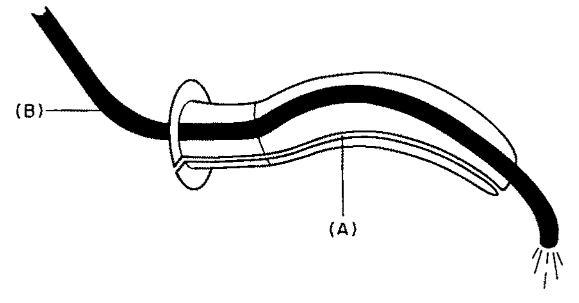

Fig. 1. Fibrescope piece introduced through the modified airway. (A) Lateral opening along the airway. (B) Fibrescope.

The bronchoscope is cautiously advanced to the carina and then it is released from the modified airway by easing it through the lateral opening of the airway which is then removed from the mouth. The tube is railroaded down over the fibrescope into the trachea and the optical equipment is finally withdrawn.

All our 20 patients were safely and successfully intubated. Our criterion for safety during the procedure was to maintain (97–100)% O_2 saturation as measured by a Nellcor-100 pulse oximeter. If the oxygen saturation is reduced during the attempt at intubation the bronchoscope is removed and the lungs ventilated by mask with 100% oxygen until the saturation recovers.

The modified grooved airway we used provides a safe method for advancement of the fibrescope to the laryngeal inlet and overcomes the acute angle at which the fibrescope must enter the larynx during oral intubation. Its unique advantage is that it can be removed after the fibrescope has entered the trachea and thus it does not limit the size of the tracheal tube.

We think that this modification makes the technique of fibreoptic orotracheal intubation immediately available to all anaesthesiologists, even to those without specific training.

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Myotonic dystrophy and respiratory function

Legal commentary on an enquiry into unexpected death after orthopaedic surgery in a patient with myotonic dystrophy[1] prompts a reminder of the role of sleep-related hypoventilation in the pathogenesis of respiratory failure in these patients and its potential importance in peri-operative management.

Inadequate gas exchange occurs during sleep in patients with chest wall restriction from a number of causes, including kyphoscoliosis,[2,3] muscular dystrophy,[4] diaphragmatic weakness[5] and pulmonary tuberculosis treated by ablative surgery.[6] Accessory muscle function is lost during sleep and intercostal activity also ceases during rapid eye-movement sleep. Hypoventilation is inevitable if the diaphragm alone is unable to maintain adequate thoraco-abdominal movement. Arousal reactions are stimulated by the consequent desaturation and hypercapnia, (see Fig. 1) and thus terminate the episode before haemodynamic consequences occur. Blunting of arousal responses by sedatives or anaesthetic agents allows the hypoventilation to continue with potentially fatal consequences.

The sensitivity of patients with myotonic dystrophy to anaesthetic agents is well known,[7,8] and their vulnerability to peri-operative complications is enhanced by an increased incidence of disturbances of cardiac rhythm. Safe awakening from anaesthesia, even when without undue delay, does not indicate that the risk has passed. Subsequent natural sleep brings renewed risk, and compounds the residual effects of surgery, anaesthesia and, above all, postoperative analgesics.

The selection of patients for higher levels of surveillance than are usual on general wards requires an understanding of the implications of associated disease as well as the consequences of the procedure. The possibility of occult respiratory muscle weakness should be considered in any patient with muscular dystrophy. Postoperative pulse oximetry, supplemented in some cases by direct or indirect measurement of arterial carbon dioxide tension, should be considered mandatory in patients in whom such weakness is suspected.

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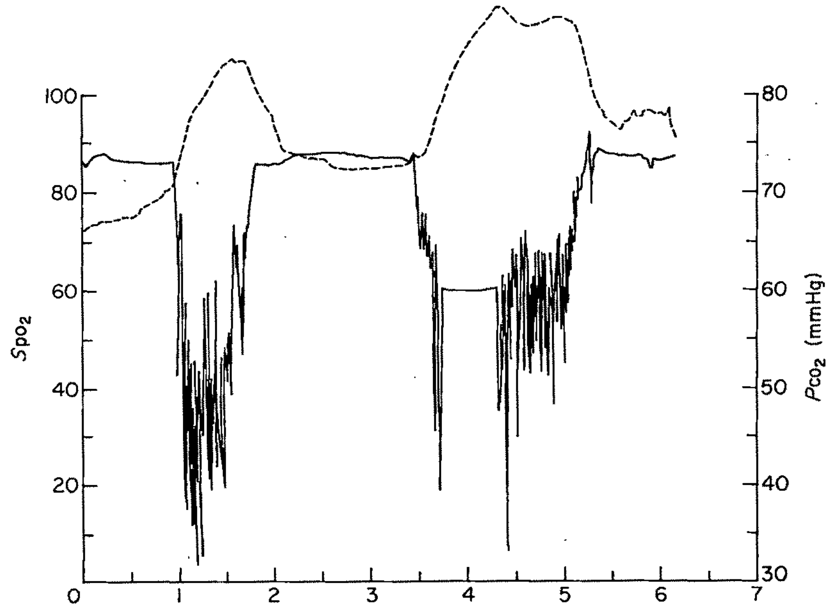

Fig. 1. Overnight recording of oxygen saturation (———) and transcutaneous carbon dioxide tension (----) in a well-built, ambulant, 39-year-old male with myotonic dystrophy. Note that transcutaneous values for carbon dioxide exceed arterial figures by approximately 1.3 kPa.

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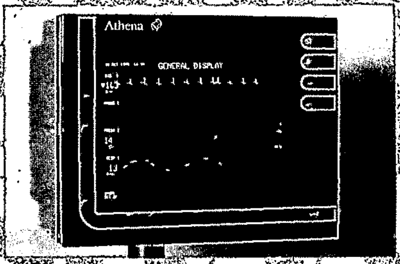

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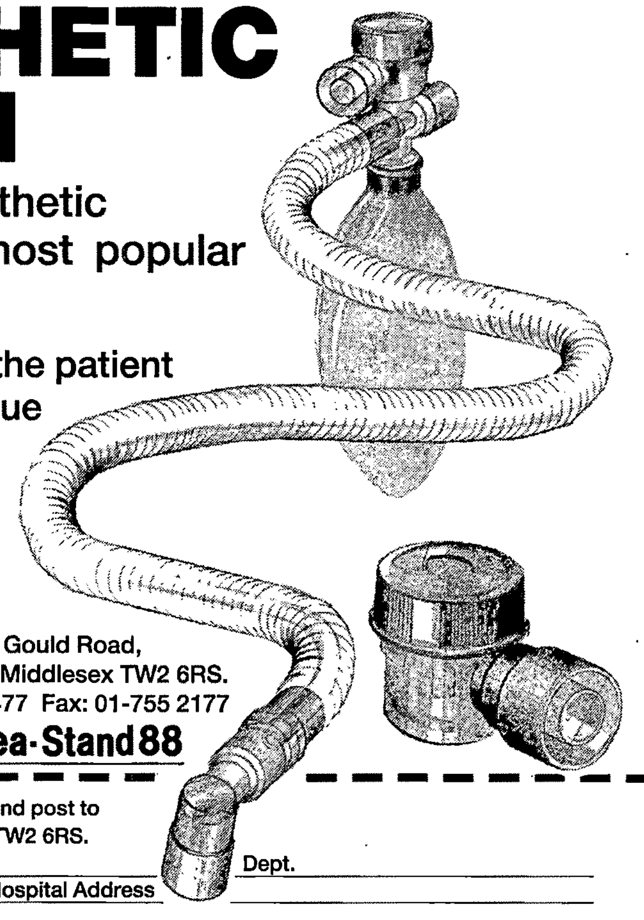

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The FEF end-tidal CO_2 detector

Drs Strunin and Williams (*Anaesthesia* 1989; **44:** 929–30), state that the ODD 'does not quantify anything and relies on the observations and experience of the user'. They are correct: the ODD does not quantify since it was designed to differentiate oesophageal from tracheal intubation.[1] They are, however, wrong to assert that the successful use of the ODD depends on the experience of the assessors. The nonanaesthetic assessors in the original study[1] included three surgeons, five nurses and a Royal Air Force paramedic, all of whom have no previous anaesthetic experience. I have, since then, instructed junior house officers, ambulance personnel and medical students in the successful use of the ODD after just 5 minutes instruction. One of the attributes of the ODD is that it is very simple to use and enables relatively inexperienced personnel to check tube placement after intubation in less than ideal conditions.[2]

It seems that the FEF detector too does not quantify the amount of end-tidal CO_2, but indicates the presence or absence of CO_2 in the gas which passes through the detector. There are two potential sources of error. Firstly, it is well recognised that after manual ventilation using a facemask, CO_2 from exhaled air may be blown into the stomach.[3,4] Acid in the stomach may, in addition, in some circumstances generate CO_2 when it is in contact with certain ingested materials.[5] Presumably, the FEF end-tidal CO_2 detector would change colour in these circumstances before reversion to the original colour, as CO_2 is washed out of the stomach. This may lead to failure to detect oesophageal intubation or cause significant delay in detection. A capnograph would be more sensitive since it quantifies the percentage of end-tidal CO_2; a decrease in end-tidal CO_2, especially when associated with an initial low value would lead one to suspect oesophageal intubation.

Secondly, good lighting conditions are required for detection of colour change and this may cause an error in less than ideal conditions and limit its use in those conditions. Users who are colour blind will not be able to use the FEF CO_2 detector.

The other disadvantage of the FEF end-tidal CO_2 detector is the potentially large deadspace of 38 ml which limits its use in children. The original ODD was successfully used in children in a preliminary trial[6] and a larger clinical trial will be completed soon.

Last, but not least, the ODD is very cheap and reusable.

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Lingual thyroid and difficult tracheal intubation

A 30-year-old female presented for an abdominal tubal ligation, dilatation and curettage, and diathermy to cervix. She was a healthy nonsmoker. No difficulty was envisaged in respect of tracheal intubation. She had received two general anaesthetics in the past (23 and 15 years ago) and no difficulty in intubation was recorded.

Premedication was with diazepam; induction was with thiopentone 250 mg, fentanyl 50 μg and 30 mg atracurium. Her lungs were ventilated easily with oxygen 33%, nitrous oxide 66%, and 2% isoflurane. A polypoid mass of tissue obscured any view of the larynx at laryngoscopy. Manual ventilation of the lungs was resumed without difficulty. Two subsequent attempts to visualise the glottis were made. Intubation was finally achieved using a bougie technique (7.0 mm Portex tube). Surgery proceeded uneventfully and the patient was extubated after reversal of the muscle relaxant. No respiratory distress occurred afterwards.

Thyroid function was normal. A thyroid scan with Technetium 99m demonstrated an area of uptake at the base of the tongue, and normal thyroid uptake was observed in her neck. A lateral radiograph revealed a suprahyoid mass.

Difficult intubation in this case was the result of a mass at the base of the tongue which was later diagnosed as a lingual thyroid, a condition first described to cause difficult tracheal intubation in 1959.[1] Lingual thyroid is an embryological remnant of the thyroid as it makes its descent from the pharynx to its normal position. Aberrant thyroid tissue is normally found in the midline along the line of the thyroglossal duct.

She had two general anaesthetics with no difficulty in intubation: dental extractions in 1974 and tonsillectomy in 1965. It seems that this ectopic tissue had increased in size, especially after her five pregnancies. It was, however, not large enough to be symptomatic and hence there was no advance warning of this intra-oral lesion.

This case represents a powerful reminder that difficult intubation can be caused by both bony and soft tissue structures. The anaesthetist should assess the factors noted and make a thorough intra-oral inspection before each case.

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'Cured' myasthenia

Lumb and Calder are to be commended for bringing their 'cured' myasthenic patient to the attention of their colleagues (*Anaesthesia* 1989; **44:** 828–30), but I am surprised that a history of myasthenia gravis from their patient did not suggest the use of a more conservative dose of vecuronium for such a short elective procedure. A simple nerve stimulator was available to them; a small test dose, for example 0.5 or 1.0 mg vecuronium, evaluated by response to nerve stimulation seems prudent.

The statement that '1.5 hours after induction, four twitches were seen with a T4 to T1 ratio of approximately 30%' concerns me. Two papers are then quoted in the discussion which demonstrate effectively that estimation of train-of-four fade to this precision using visual assessment of evoked thumb twitch is impossible.[1,2] What Lumb and Calder actually observed were four twitches, with train-of-four fade still present. This limitation to the use of visual or tactile assessment of evoked thumb twitch needs to be stressed, rather than simply dismissed, since the observation of Lumb and Calder could represent a train-of-four fade ratio anywhere between 0.01 and 0.99, depending upon circumstance and their own experience.[2]

The paper quoted by Lumb and Calder supporting a train-of-four fade ratio of 0.5 as indicative of adequate clinical recovery of neuromuscular function is taken out of context;[3] the report described this ratio in relation to atracurium-induced neuromuscular blockade and equated the train-of-four ratio at reversal with *subsequent* evidence of residual neuromuscular blockage in the recovery room. Neither in the paper quoted, nor in the original report,[4] was any attempt made to correlate simultaneously a train-of-four ratio of 0.5 with variables which indicate adequacy of neuromuscular function. The uniquely rapid offset of atracurium-induced neuromuscular blockade makes it likely that a train-of-four ratio of 0.5 will not indicate adequate recovery from any of the other currently available competitive neuromuscular blocking agents; a train-of-four ratio above 0.7 indicates adequate clinical recovery from tubocurarine-induced blockade,[5,6] but to my knowledge a 'safe' ratio for vecuronium is yet to be determined.

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A reply

Thank you for the opportunity to comment on some of the points made by Dr Smith. Of course, with hindsight, our management of neuromuscular blockade in this patient would have been different, and similar to that mentioned by Dr Smith. However, had time allowed a review of the literature before anaesthesia, we would have discovered that the most recent review[1] suggested that myasthenic patients in remission respond normally to non-depolarising muscle relaxants. Nevertheless, Azar does recommend the use of small doses in such patients. We were lulled into a false sense of security by our patient's outstanding athletic ability.

We agree that visual assessment of thumb twitches has limitations, but this was all we had available to us for a routine gynaecological list. 'A T4 to T1 ratio of approximately 30%' was not meant to imply an accurate assessment of the T4 to T1 ratio, but simply to indicate that four twitches were definitely present and therefore an attempt at reversal was likely to be worthwhile.

The precise T4 to T1 ratio at which clinical recovery occurs clearly varies with different agents,[2] and we also know of no study using vecuronium. We were merely attempting, in our quotation of Pearce *et al.*[3] about clinical recovery from atracurium, to illustrate the concept that lack of clinical symptoms does not guarantee normal function of all neuromuscular receptors.

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Ketamine and shivering

We studied 30, ASA 1 and 2, patients for different types of surgery under spinal, epidural or general anaesthesia in which halothane was used as one of the anaesthetics. There were 10 patients in each group. Ketamine was given in a dose of 0.5 mg/kg intravenously as and when the patient developed shivering during regional anaesthesia or in the recovery room after general anaesthesia. Temperature was monitored with a Datex Cardiocap. Shivering was controlled within 60–90 seconds of the injection. There was immediate increase in body temperature and this increase persisted for 10 minutes and then decreased. The majority of patients were mildly sedated but arousable. The patients had no sensation of coldness. A second dose of ketamine was required after 10 minutes in six patients. The drug

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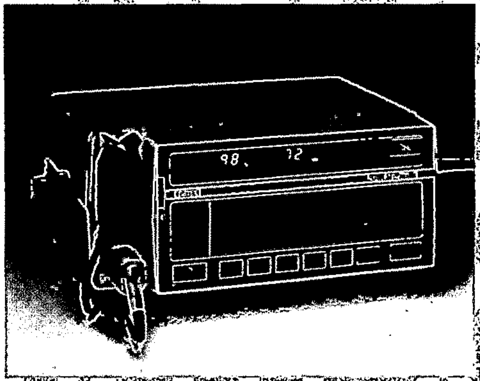

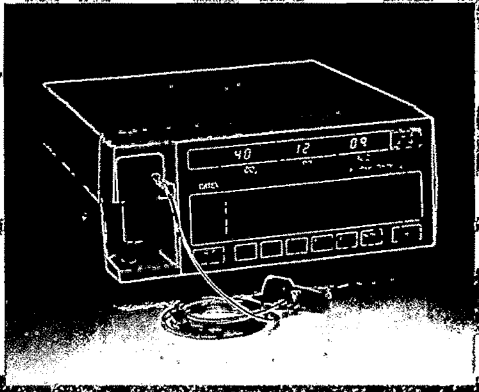

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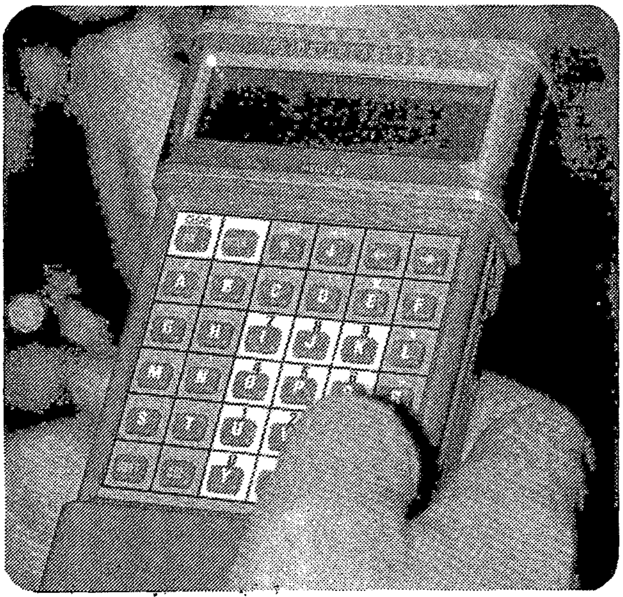

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Applications should be submitted by 30th April 1990 appeared quite useful in spinal and epidural anaesthesia where it also provided sedation and analgesia. Increase in the blood pressure and pulse rate was not a problem in these patients. Two patients developed hallucinations which were controlled by intravenous lorazepam (4 mg intravenously). Four patients had delirium. Three patients developed postoperative vomiting.

Hypothermia is the usual cause of shivering; in the case of spinal and epidural anaesthesia it is the vasodilatation with the rapid infusion of fluids which is responsible for intra-operative shivering. Halothane was shown to increase shivering after operation. This shivering is secondary to vasodilatation and the consequent heat loss caused by inhibition of sympathetic nerves.[1] Ketamine probably controls shivering by nonshivering thermogenesis[2] either by an action on the hypothalmus or by beta adrenergic effect of noradrenaline. The mechanism of heat production is likely to be either an uncoupling of oxidative phosphorylation of mitochondria in fat in the presence of high concentrations of non esterified fatty acids, or stimulation of lipolysis–lipogenesis cycle with ATP utilisation and heat production.[2] Engelman and Lockhart[3] have stated that in children, halothane, nitrous oxide in oxygen anaesthetic produced a greater decrease in temperature than ketamine. Low dose ketamine is an alternative to the existing drugs to control shivering.

IGMC, D.R. Sharma
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Effective peri-operative pain management in cancer patients

Drs Clark and Davies draw attention (*Anaesthesia* 1989; **44:** 935) to the problem of adequate postoperative pain relief in patients who are already taking oral controlled-release morphine sulphate for cancer pain. They rightly point out that not only should these patients continue to receive an equivalent analgesic parenterally but that also they may require a larger dose to prevent the pain caused by the surgical operation.

This may be achieved by a simple regimen: on the morning of operation omit the oral morphine but give intramuscular morphine in a dose equivalent to 25% of the morning dose of oral morphine. Then set up an intravenous or subcutaneous continuous infusion of morphine equivalent to 50% of the total daily dose of oral morphine. This should be given over 24 hours. Occasional parenteral top-up doses of morphine may be needed.

If an immediate operation is required a 24-hour infusion of morphine equivalent to 50% of the daily dose of oral morphine should be started at the time of operation.

It is important that other treatment such as antiemetic and anxiolytic drugs should be continued also.

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Drs Clarke and Davies (*Anaesthesia* 1989; **44:** 935) are quite right to plead for adequate postoperative pain relief for cancer patients taking opiates. Other patients taking opiates before operation should be included as well (e.g. for peripheral vascular disease). We have successfully used patient-controlled analgesia (PCA) in our hospital for such patients.[1] This takes all the guesswork out of the prescription of analgesics. We normally do not use background infusions with PCA[2] after operations, but this is one group of patients for whom this is suitable. Finally, their letter demonstrates once again the inadequacy of teaching on pain control.

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Pain after laparoscopy

Dr R. McKenzie (*Anaesthesia* 1989; **44:** 450) reports the peri-operative topical application of 1% etidocaine to the fallopian tubes as a means of abdominal pain reduction after laparoscopic sterilisation. It has been suggested that pain after laparoscopic sterilisation has two origins.[1] Subphrenic and shoulder-tip pain appear to arise from the persistence of intraperitoneal carbon dioxide which irritates the diaphragm and phrenic nerve; this pain appears to be aggravated by ambulation; in one study the frequency of upper abdominal pain decreased during the first night only to increase the next day when patients returned home.[1] Intraperitoneal gas can be detected radiologically in a high proportion of patients until the third day after operation, and aspiration of this gas relieves the pain.[2]

Pelvic pain can originate from the use of rings, clips or diathermy to interrupt the fallopian tubes.[1] We appreciate that McKenzie's method may relieve pain in the pelvis but wonder what influence it has on gas-mediated upper abdominal discomfort.

We have encountered a group of patients in whom immediate postoperative pain is aggravated by the supine posture, but is relieved by sitting up to 45°. We suggest, therefore, that a third factor in pain after laparoscopy is gravity-dependent tracking of blood or free fluid from the operation site, particularly the umbilical stab wound, through paracolic gutters to irritate the diaphragm. Studies are in progress to test this hypothesis.

It is now our routine practice to keep these patients semirecumbent as soon as they have fully recovered from anaesthesia.

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J.S. Thomas
P. Bowen-Simpkins

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The cost of propofol

Dr J. McWilliam (*Anaesthesia* 1989; **44:** 866) has questioned the use of propofol in day surgery in 'an increasingly cost-conscious NHS'. His retrospective study compared small, unequal groups of patients anaesthetised for 'standard common procedures' in different years (1985 to 1987), and the cost of anaesthetic drugs (excluding inhalation agents) was the only outcome reported. No mention was made of demographic data or dose requirements and no evidence was presented to suggest that the study groups were comparable.

Propofol is undeniably more expensive than the currently available alternatives but it has achieved widespread popularity amongst anaesthetists and many of its advantages are pertinent to day-case anaesthesia. Firstly, recovery from propofol anaesthesia is rapid and clear-headed; this compares favourably with other intravenous[1] and inhalational techniques.[2] Secondly, the low incidence of nausea and vomiting after propofol suggest that it may possess intrinsic antiemetic actions.[3] Clearly, in the Day Stay environment it is advantageous if patients, who are starved from the night before admission, are able to drink or even take a light snack before discharge. Thirdly, the use of supplemental narcotics has been shown to be unnecessary for day-case gynaecological and urological procedures[4,5] when propofol is used. Fourthly, propofol is a convenient agent to use in association with the laryngeal mask airway and is used to facilitate tracheal intubation;[6] this avoids the morbidity associated with use of suxamethonium. Fifthly, propofol may be used to maintain anaesthesia during short procedures without inhalational agents. The cost of nitrous oxide is underestimated[7] and the dangers inherent in its use (such as the delivery of hypoxic mixtures) add complexity and expense to anaesthetic delivery systems. Furthermore, the cost of delivering isoflurane alone at high fresh gas flows exceeds that of propofol administered by a recommended manual infusion scheme.[8] Volatile agents were not costed by Dr McWilliam.

Dr McWilliam went on to mention the recent warning of the Committee on Safety of Medicine's about anaphylaxis and convulsions associated with propofol.[9] These reports should be considered in context. Most intravenous anaesthetics can trigger hypersensitivity reactions and the comparative incidence and severity of reactions after propofol has yet to be established. If the use of propofol results in the use of fewer drugs, the overall incidence of all idiosyncratic reactions (anaphylaxis, malignant hyperthermia) should also be reduced, quite apart from any financial saving.

The study by Dr McWilliam is a timely reminder that we must prepare for critical appraisal of our use of resources. With the continuing 'roll-out' of the resource management initiative it is imperative that anaesthetists embrace the principles of clinical audit and cost : benefit analysis. Armed with this information we can present a cogent case to our managers for more resources for equipment and ensure that new anaesthetic techniques receive adequate clinical evaluation. The establishment of an Audit (Quality of Practice) Unit by the College of Anaesthetists is an important step in this direction.

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The letter from Dr McWilliam, a Community Physician, (*Anaesthesia* 1989; **44:** 866) about the costs of propofol cannot be allowed to go unchallenged.

Firstly, he has confused the *risks* of giving a drug with its *cost*; the risk of anaphylaxis, the most dangerous drug reaction, has been estimated to be 1 : 20 000[1] with thiopentone with which propofol compares favourably at approximately 1 : 60 000.[2]

Secondly, his study suffers from several basic errors. Which anaesthetics were used in his retrospective comparison? He has chosen to ignore the cost of inhalational agents, although the usage of these has almost certainly changed in the interval between his study years. Many anaesthetists[3-5] do not use inhalational agents in day surgery, so to omit these from costing invalidates the study (Table 1). What he appears to have compared is the cost of propofol with that of thiopentone; a telephone call to the Hospital Pharmacist could have given him this information.

The fact that he could not find a contemporary comparison group would suggest that other anaesthetists agree with our opinion[3] that propofol is the current anaesthetic of choice for day surgery because of its rapid and pleasant

Table 1. Costs of anaesthetic drugs.

		£
Thiopentone	2.5%, 20 ml	1.14
Methohexitone	1%, 10 ml	0.70
Propofol	1%, 20 ml	3.51
Propofol (infusion for 70 kg adult)	8 mg/kg/hour 0.933 ml/minute	0.16/minute
Halothane 2%	0.525 ml/minute	0.01/minute
Enflurane 3%	0.900 ml/minute	0.16/minute
Isoflurane 3%	0.914 ml/minute	0.39/minute

Volumes of inhalational agents/minute calculated by Dr K.L. Dorrington, Nuffield Department of Anaesthetics, Oxford. These assume an atmospheric pressure 100 kPa, an ambient temperature 20°C and a fresh gas flow 6 l/minute using a Magill or Lack system. The costs of other % inhalational agent or fresh gas flow may be calculated as a simple proportion of the figures given. Costs as given by Hospital Pharmacy include VAT.

recovery, low incidence of postoperative morbidity and improved subjective feelings of wellbeing.

If cost-saving is the issue, then any measure which makes day surgery more acceptable is surely to be encouraged.[6] We are successfully carrying out endometrial resections (a possible alternative to hysterectomy) and laparoscopic sterilisations as afternoon day cases in Oxford: propofol infusion is an essential part of our technique; without it, the admission rate is unacceptably high.

Is Dr McWilliam's letter an awful warning of the thinking which might prevail if the proposals suggested in the White Paper are implemented, with nonclinicians seeking to influence practice on shaky and ill-considered financial grounds?

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Convulsions and propofol

The literature about the potential convulsive properties of propofol is confusing to say the least. There is, on the one hand, a clearly demonstrated decrease in seizure duration after electroconvulsive therapy in patients anaesthetised with propofol, compared with those anaesthetised with methohexitone.[1] This suggests that propofol has some anticonvulsant properties.

There are on the other hand numerous reports of opisthotonus and *grand mal* convulsions after anaesthetics which have included propofol administration.[2-4] Unfortunately, the situation is not quite so straightforward, since in all of the cases where signs of central nervous system excitability were noted, propofol was not the sole drug administered. (All these cases included an opiate as part of the anaesthetic technique, and as fentanyl is known to increase plasma propofol levels by as much as 50%,[5] this somewhat complicates the picture.)

It is difficult to be certain what the exact cause of an adverse reaction is when a mixture of drugs has been administered, but the suggestion is clearly that propofol is the culprit.

This is a report of a case which goes some way to clarify the situation. The patient was a previously fit 28-year-old female who weighed 65 kg and presented as a day patient for manipulation under anaesthesia of her lumbar spine. She had undergone a similar procedure uneventfully 2 years previously when thiopentone was used as the single anaesthetic. Her anaesthetic on this occasion consisted of 160 mg propofol intravenously. Manipulation was begun when the eyelash reflex was lost. The surgeon commented, after approximately 30 seconds, that he did not believe the patient was fully relaxed, so a further 40 mg propofol was given. The patient breathed 100% oxygen for the rest of the procedure, which lasted approximately 2 minutes and was uneventful.

Recovery was rapid and uncomplicated, and it was noted that she was talking and behaving quite normally within a matter of minutes from the end of the procedure. Thirty minutes after the end of the anaesthetic the patient had a totally unexpected *grand mal* convulsion; 15 mg Diazemuls were required to control the fits.

She had repeated short *grand mal* episodes over the next 3 hours interspersed with myoclonic jerks of the right arm and leg. These were all self-limiting and did not require further specific treatment. The patient was not quite conscious throughout this period but was easily rousable and protected her own airway. She was observed overnight on the intensive care unit.

Physical examination was normal the next day. It was, however, revealed that at the age of 2 years, she sustained a fractured skull after a fall but suffered no sequelae. She was investigated for *petit mal* epilepsy at the age of 11 years but the diagnosis was discounted. An electroencephalograph (EEG) performed 3 months after her anaesthetic was reported as normal and medical follow-up for a further 3 months showed that she had had no subsequent problems.

This case did not, unlike previously reported cases, involve the administration of any other anaesthetic agents except propofol. The patient had previously undergone the same procedure uneventfully under thiopentone anaesthesia, and medical follow-up, including an EEG, were normal. All these points strongly implicate propofol as the causative agent of the postoperative problems in this patient.

The Committee on Safety of Medicines had by October 1989 received 101 reports of suspected adverse reactions involving CNS excitability associated with the use of propofol. (Committee on Safety of Medicines, personal communication.) These ranged from benign twitching to frank *grand mal* convulsions. These 101 cases account for approximately 25% of all adverse reactions which involved propofol and were reported to the CSM up to that time. It is obvious that this represents a major drawback to what is otherwise an excellent drug.

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Rapid inhalational induction using isoflurane in children

Philips *et al.* (*Anaesthesia* 1988; **43:** 927-9) identified desaturation below 85% in 24% of children when conventional inhalational induction was performed with isoflurane, whereas desaturation between 85% and 90% occurred in only 4% when halothane was employed.

Several techniques for rapid inhalational induction of anaesthesia, which are acceptable to adults, are described and the concepts involved are discussed by Drummond.[1] The relatively low blood solubility of isoflurane should promote rapid induction and, with short procedures (such as those commonly performed on a children's outpatient population) rapid emergence.

Rapid inhalational induction has been achieved in adults, with induction times of 38 seconds for 5% isoflurane and 86 seconds for 3.5% halothane,[2] although these patients were pretreated with fentanyl 200 µg intravenously. Isoflurane 2% was used without pretreatment but no information on induction times was given.[3]

A pilot study to examine the usefulness of 5% isoflurane for rapid inhalational induction of children who have brief procedures is reported. Twenty-five unpremedicated children aged from 7 months to 13 years of age were studied. Older children were instructed to breathe deeply three times through the mask; younger children, who could not cooperate, simply had the facepiece applied firmly but gently. The gas mixture did not include nitrous oxide since this appears to promote excitatory phenomena,[4] and comprised 5% isoflurane in 95% oxygen at high flow (initially) through an appropriate breathing system. Loss of consciousness was rapid but took more than three breaths in the larger children, and induction for dental extraction was achieved in 45–60 seconds. A pulse oximeter was attached in every case and desaturation below 90% did not occur. Excitatory phenomena were notably uncommon; a cough or transient breath-holding occurred in five subjects after 30–45 seconds. Overall induction was considered smoother than conventional isoflurane induction.

Unfortunately, the older children found the odour particularly unpleasant so the technique is not advocated for routine use. However, inhalation of 5% isoflurane in 95% oxygen is considered a potential alternative to halothane if circumstances dictate.

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Monitoring during aeromedical transfer

In their interesting letter (*Anaesthesia* 1989; **44:** 867) on the use of pulse oximeters in mountain rescue and helicopter evacuation Drs Puttick and Lawler noted their surprise at the maintenance of normal function of the four pulse oximeters despite extreme vibration in the Sea King helicopter. My colleagues and I, who provide anaesthetic and intensive care cover for the world-wide Royal Air Force aeromedical service, have also made this observation. We have used the Criticare 501 and Ohmeda Biox 3740 pulse oximeters on many occasions in a wide variety of aircraft ranging from jet transports (Tristar, VC10, HS125) to propeller transports (Hercules, Andover) and helicopters (Puma, Chinook).

A more surprising observation, perhaps, is the lack of interference in the operation of the Critikon Dinamap 8100 on these same aircraft. This apparatus measures blood pressure noninvasively by the sensing of transmitted pressure waves from an occlusive cuff. The readings appear to be unaffected by engine vibration even in helicopters. An important point that should not be overlooked is the potential interference between aircraft electronics and electrical medical equipment or vice versa, especially with the increasing sophistication of aircraft technology including fly-by-wire systems. We have not yet experienced difficulties with interference. Our equipment has undergone substantial investigation to test its electrocompatibility with various types of aircraft. Further testing on newer equipment is underway. The testing is carried out by the electronics branch at RAF Boscombe Down.

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Portable monitoring devices

Your correspondents (*Anaesthesia* 1989; **44:** 619) emphasise the need for reliable miniportable monitoring systems for use during transport of patients from the induction room to the operating table and from the operating room to the recovery room. The currently available monitoring systems are very bulky and, if portable, are expensive. We report two devices which are very useful. They can also be used for routine monitoring if other instruments are unavailable, particularly during transport to hospital, in remote areas and in Third World countries. The devices are relatively inexpensive and are widely available in sports equipment stores as 'pulse monitors' to monitor the pulse during exercise.

Device I is a TRX wrist-watch style cordless pulse monitor, model PU 801 and device II is a TRX wrist-watch style pulse monitor, model PU 701 (Fig. 1).

Device I. The unit consists of a pulse watch, a chest belt with special conductive rubber (functions as ECG electrodes), and an ECG pulse transmitter. The unit employs the same measuring method as electrocardiographs to monitor the heart rate accurately. The chest belt is strapped around the chest with rubber electrodes positioned below the left nipple. The ECG transmitter when clipped to the rubber electrodes picks up the QRS signal and transmits it to the watch within a range of 3 ft. The watch, when set in pulse mode, displays the heart rate. Each beat is accompanied by a beep and flashing heart sign.

Device II. This is similar to I but it is used with a fingertip sensor. The finger is introduced into the sensor up to the point where the skin of the finger touches the bump inside the sensor. The sensor is connected to the watch by a 23 cm length cord. The unit measures the pulse by the method of opto-electronic pulse detection (infrared plethysmography). The finger sensor contains a small infrared light source and photodetector. The infrared light is projected into the peripheral blood capillaries. Some of the light is absorbed by the tissues. The light absorption coefficient of blood is higher than that of the surrounding tissues so an increase in the amount of blood causes a decrease in the total amount of light detected. The photodetector picks up the light which emerges from the skin. The extent of difference is analysed as a pulse. The watch displays the pulse rate when set in pulse mode. Each pulse is accompanied by an audible beep and flashing heart sign. Both instruments have built-in pulse rate alarms and the range can be set easily. The units sound an alarm if the heart rate falls beyond the set range.

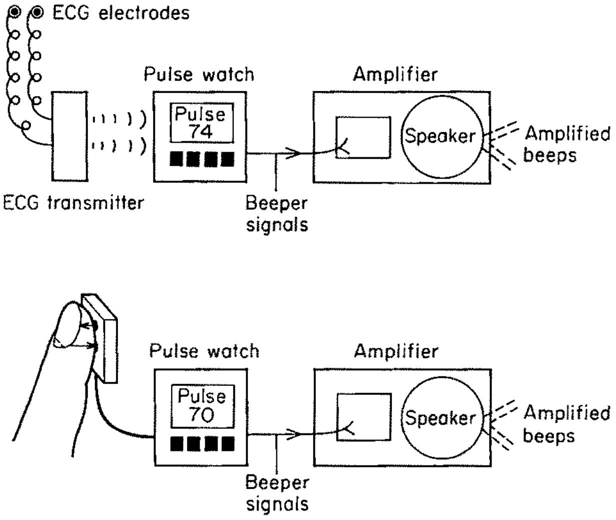

Fig. 1. *Top:* device I; *bottom:* device II.

These two devices can be used unmodified to monitor pulse but have certain disadvantages. We have made a few modifications on these instruments to suit our needs. The audibility of the beep is amplified by using a suitable amplifier (portable radio or a mini cassette recorder). In this instance we have used a mini cassette recorder as an example. The electric signals from the beeper of the pulse monitor units are fed directly into the circuit board instead of the signals from audio playback head. The beep can be amplified by switching the playback switch of the mini cassette recorder and the volume adjusted to an optimum level. A suitable, less expensive amplifer could be designed. The motor is disconnected to conserve battery power if a mini cassette recorder is used.

The lithium batteries which supply the power to the pulse monitor units and the ECG transmitter are replaced with two cheaper conventional pen light cells (1.5 volts) to increase the life of the battery considerably and reduce operational costs.

The chest piece (ECG transmitter) of device I can also receive signals from conventional clip-on ECG electrodes (placed at positions V1 and V6 respectively) instead of using rubber electrodes which need to be strapped to the chest. An extra length of wire can be placed between the clip-on ECG electrodes and the terminals of the ECG transmitter. This would enable the ECG transmitter to be placed away from the patient and within 3 ft of the receiving pulse watch. The cord for the finger sensor of device II is increased by extra length as desired.

These modifications can be carried out by the hospital medical technicians. The units without the amplifier would cost £100 for device I and £45 for device II. Pulse plethysmography can be used to monitor the patients during transfer, but the plethysmograph sensors are very sensitive to movements which are difficult to avoid and may result in considerable artifacts. Device I is more reliable and free from artifacts under these circumstances and works satisfactorily even when there is peripheral vasoconstriction.

We have found these units to be light weight (350 g), inexpensive, portable and convenient practical devices to ensure continuity of care during transport of patients to the recovery room and can be used as an adjunct to continuous manual palpation of the pulse.

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Modifications to expiratory valves

Many older anaesthetists like myself regret the muting of the Heidbrink valve inherent in modifications for scavenging. The hiss of the expiratory valve of the Magill attachment provided audible information about rate, rhythm and depth of breathing and also gave a non-directional indication of both an adequate airway and a gas-tight seal when anaesthesia was administered by mask.

It occurred to me that the old reassurance could be restored by simple electronic means: a small microphone could be inserted into the system near the valve. This works very well applied to the Bain apparatus by placement in the bag mount (Fig. 1). We use an electronic device (Cortest Monitoring System)* originally intended for an oesophageal stethoscope, but simple components can be obtained from ordinary radio stores, as shown in the Figure (Tandy: Electret Tie Clip Microphone and Mini audio amplifier). Probably one of the amplifier/loudspeakers available for personal hifi systems could also be used.

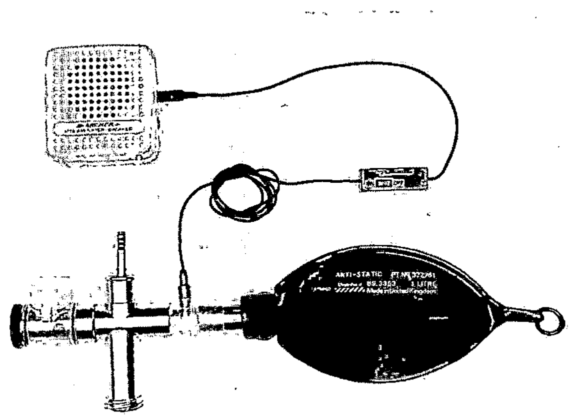

Fig. 1.

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Ephedrine and hypotension

Drs Wood, Foley and Lawler are to be congratulated for their bravery in publishing their letter (*Anaesthesia* 1989; **44:** 869). Eleven litres of intravenous fluid seems to underline what is known to be true: fluid given to attempt to correct hypotension after epidural top-ups is rarely successful.

Ephedrine would appear to be the treatment of choice. Given incrementally there is usually an effect on the blood pressure but little on the fetus. Perhaps it would have been wiser to give more than 19 mg rather than further fluid?

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Erroneous explanation for an erroneous pulse oximeter reading

We cannot allow Dr Hopkins' comments on pulse oximetry to go unchallenged (*Anaesthesia* 1989; **44:** 868).

Clinical signs of hypoxaemia are unreliable. It was demonstrated in 1947 that the majority of clinicians cannot detect cyanosis until the oxygen saturation is below 80%.[1] It is therefore not surprising that Dr Hopkins did not notice cyanosis when the oximeter read 90%. This clearly demonstrates the increased margin for safety inherent in the use of pulse oximetry.

The basic principle of pulse oximetry is that the oximeter differentiates between the constant absorption of light by immobile substances and the pulsatile absorption associated with blood flow underneath the probe.[2] One would therefore expect that the constant absorption of light by dried blood on the patient's skin would *not* affect the pulse oximeter reading.

We carried out a simple experiment. We both demonstrated that a pulse oximeter gave identical readings from both our right and left index fingers. We then liberally coated the index finger of one hand with autologous blood, and allowed it to dry. We compared the pulse oximeter readings from the right and left index fingers. The presence of external dried blood made no difference to the reading.

Dr Hopkins should look elsewhere for the explanation of the patient's desaturation. We suggest that the probe might have become displaced when the patient was turned prone, or that rubbing the digit during cleaning improved tissue perfusion.

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An unusual occlusion of an anaesthetic system by a polythene drape

An otherwise fit 46-year-old woman was anaesthetised for the operation of myringoplasty. She was covered with an adhesive polythene drape (Steridrape). The patient's head was moved during the procedure and, shortly after this, a disconnexion of the system at the catheter mount was detected. It proved impossible to inflate the patient at all after reconnexion under the drapes. The drapes were removed rapidly and the system dismantled to reveal that during reconnexion a portion of the polythene drape had been punched out, and formed a diaphragm across the lumen. No ill effects were suffered by the patient.

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A nasogastric tube as guide during difficult oesophagoscopy

Recently, a 40-year 40.9 kg male patient, who was suspected to have a neoplasm in the lower oesophagus, was presented for examination including oesophagoscopy under anaesthesia. There was some restriction of mouth opening, caused by a lesion in the right pharynx, but difficulty with tracheal intubation was not anticipated. However, after induction with thiopentone and manual mask ventilation with oxygen after suxamethonium, only the proximal pharynx immediately adjacent to the uvula and soft palate could be seen with a laryngoscope and blind nasal intubation was performed with a stylet-curved 6.5 mm cuffed plastic tube.

The surgeon was unable to introduce the rigid oesophagoscope into the oesophagus and he intended to abandon the procedure. It proved possible, however, to pass a standard nasogastric tube through the nose and down the oesophagus and, by following this guide the surgeon was able to examine the tumour with the rigid endoscope in the distal oesophagus.

It is possible that this method might help in other difficult situations.

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Protection of the laryngeal mask airway

It is recommended that once a laryngeal mask airway is in place, a bite-block be inserted to ensure that the tube is not occluded by the patient biting on it.[1] Some authorities recommend the use of an oral airway.[2] The most common bite-block available in most hospitals is the oral airway (Guedel type), although a wooden mouth wedge, dental prop, or London Hospital airway prop could also be used. The use of a Guedel airway can frequently be difficult because the tip of the airway abuts onto the upper edge of the cuff and may prevent the correct placement of the airway. If this occurs protection against biting cannot be assured.

The use of a bite guard from a fibreoptic gastroscope over the laryngeal mask is convenient, easy to insert and gives good protection to the tube whilst in place (Fig. 1). The bite guard is placed onto the laryngeal mask tube before insertion so both placement and protection of the tube occur with one move. Access to the pharynx for suction is easy. The laryngeal mask can be withdrawn through the bite guard as the patient begins to waken and then removed altogether when it is no longer required. A bite guard is not recommended for patients with capped teeth but should be replaced by a wedge or gauze roll placed between the molars.[3]

This procedure improves the safety of the airway and protects the laryngeal mask.

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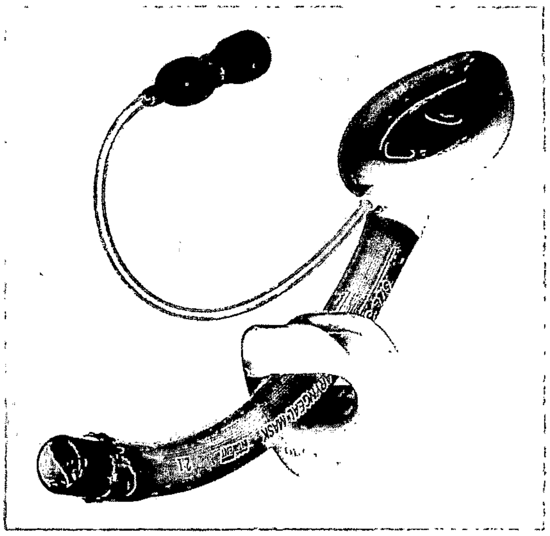

Fig. 1.

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Mydriasis in an anaesthetist

We wish to report an incident which occurred during a cardiac surgical list. A registrar prepared drugs for anaesthesia including: etomidate, pancuronium, fentanyl, heparin, atropine, methoxamine, calcium chloride and glyceryl trinitrate. No untoward incident was noted such as the splashing of drugs onto the face.

Approximately 30 minutes later, during central venous cannulation the registrar noted mild photophobia and blurred vision. An observer noticed the presence of a massively dilated and fixed right pupil.

An ophthalmologist examined the eyes within an hour. There was no abnormality other than the fixed, dilated pupil and slightly reduced visual acuity which was correctable to 6/6 vision with a pinhole. The pupillary dilatation was not reversed by pilocarpine 0.1% drops and only minimally by topical pilocarpine 4%. Such a pattern of response was diagnostic of a pharmacologically induced mydriasis rather than that of an oculomotor palsy or a Holmes–Adie pupil. Pupil size and vision were restored to normal 12 hours after the incident.

It was assumed that a drug with mydriatic properties had unwittingly entered the eye during the preparation of drugs. The most likely mode of transfer was from the fingers to the eye. Both atropine and methoxamine produce mydriasis by their respective anticholinergic and sympathomimetic properties. However, the rapid speed of onset and resolution of the pupillary dilatation were highly suggestive that methoxamine was responsible. Such an incident is an occasional event among medical personnel, and the possibility of the presence of a third nerve palsy secondary to a posterior communicating artery aneurysm may produce much alarm in the subject.

We wish to alert others to the risk of contamination of the eye, by drug or infected material. This occurred here without the subject being aware of the introduction of foreign material.

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Anaesthesia, 1990, Volume 45, pages 261–262

Book reviews

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Anaesthesia data book—a clinical practice compendium

R.A. Mason .Pp. 529. Churchill-Livingstone, 1990. £24.95.

This book, as its name suggests, is a compendium divided into six sections: medical disorders and anaesthetic problems, pre-operative and peri-operative drugs, peri-operative emergency conditions, miscellaneous problems, cardiopulmonary resuscitation and normal values. There is also a list of useful addresses which one can never find when they are needed for example that of the Malignant Hyperthermia Unit, Leeds.

A glance at the book shows that it is not one for reading from cover to cover, but one to be dipped or delved into; its arrangement is alphabetical 'dictionary' type order, and this makes cover-to-cover reading difficult. Therefore I carried it about with me for 2 months and consulted it regularly; carrying it is a bit of a problem because it is both hardback and just too large to fit in a coat pocket.

Parts of it are excellent, particularly the sections on Medical Disorders and Peri-operative Problems. The medical conditions mentioned were legion, including both common (hypertension) and rare (the Marcus Gunn Jaw Winking Syndrome). The book usefully described the 'rare' in adequate detail, although I found the common a little overdone for my tastes (although not my registrar's). Like any book, I did not agree with everything, but there were useful recipes and tips for the uncommon, although not all the syndromes mentioned in differential diagnosis (e.g. Taurius, in 'rhabdomyolysis') are referred to elsewhere.

The section on drugs did not measure up to the standard set in the section on Medical Disorders. Drugs were dealt with under group headings such as 'Anti-arrhythmics', but could appear under other headings. For example, verapamil appeared in the 'Pre-operative' section under 'Anti-arrhythmics', then, in the same section, under 'Calcium channel blockers'. It appeared again under 'Anti-arrhythmics' in the 'Peri-operative Drugs' section. The relevant texts were virtually identical. This is irritating, and I believe the two sections could be combined and edited down.

This is potentially an excellent book. The index needs to be improved, with, for instance, page running headings (like a dictionary), particularly since each section is arranged in alphabetical order. The book should be left lying in theatre suites (or wherever anaesthetists graze) for both browsing and quick reference. Unfortunately, unless it is tied down, it will quickly find its way into (outsize) pockets. Because there is no other book like it (other than Katz: *Anaesthesia and uncommon diseases*), it should go to a further edition, although I hope with some rationalisation and presented in paperback form to fit ordinary pockets.

My task was enjoyable and, despite my reservations, I am quite happy to keep the review copy; it will keep me one step ahead of my Senior Registrars!

P.G.P. Lawler

Anaesthesia and intensive care

N. Soni. Pp. 225. Heinemann, 1989. £27.50.

When I read the preface I thought I would enjoy reading this book: indeed, not only did I enjoy reading it, but I also felt that the information presented will benefit all grades of medical and nursing staff. The book is very well illustrated and each technique is concisely described and highlighted between vertical lines for the reader.

The first chapter on intravenous access is well set out. It moves from the simple peripheral technique to the establishment of central and arterial lines. It ends with an interesting discourse on the association between vascular access and modern techniques of dialysis. The second chapter concerns itself with several thoracic procedures which are all well explained. The management of a chest drain is excellent and will be particularly useful for those staff who do not deal with chest drains routinely. However, your reviewer was somewhat surprised to read that 'ventricular fibrillation may need rapid correction'. Perhaps *may* should be deleted and need changed to *needs.* The third chapter describes various abdominal procedures which are adequately covered but perhaps the more specialised techniques (suprapubic catheterisation) should be left to experts in the field.

The chapter on airway procedures is sound and full of good sense. More attention could have been paid to the recognition of a difficult airway and more caution advised when laryngeal masks and modified nasal airways are to be used. The chapter on regional blocks is interesting. It does not contain enough information to satisfy an anaesthetist but it would certainly be educational for other medical staff. The policy to precede each description of a technique with a list of specific contraindications is most appropriate. The final chapter discusses simple but important techniques. The section on intracranial pressure monitoring could be expanded particularly since the incidence of admission to hospital of patients with head injuries is increasing. The appendices also contain very helpful information.

This book should be read by all trainees who wish to be involved with intensive care. Indeed, such a book would not be out of place in the libraries of final year medical students, housepersons or nursing staff. It represents good common sense, a proper approach and value for money.

R.S. Vaughan

Anaesthesia and malignant disease

Edited by J. Filshie and D.S. Robbie. Pp. xv+303. Edward Arnold, 1989, £27.50

Some 10 years ago I found myself responsible for the provision of anaesthetic services for a busy regional and supraregional oncology unit. We ran through the whole gamut of resection, major head and neck surgery, isolated-limb perfusion, staging laparotomy in bleomycin-treated patients, and all the catheter implantations, and radiotherapy procedures associated with these patients. I find myself therefore in the position of Bernard Levin who, when reviewing a book on Mozart's librettist, read what he always wanted to have written but never had had the time!

When providing an anaesthetic service for a surgical superspecialty, and surgical oncology is evolving to become one, it is essential for the anaesthetist to be fully conversant with the range and implications of the treatment. This is particularly important during the postoperative visit, since the anaesthetist is frequently confronted with a patient just coming to grips with the realisation of the diagnosis.

The authors and editors of this book have covered the whole span of surgical oncological practice with the detailed information which I would have prized when starting out in this field. The basic chapters on pathology, chemotherapy, and immunology are useful source information. In addition, the book deals with diagnostic procedures, radiotherapy, and the insertion of catheters, areas which are not well covered in other texts. Some of the authors fall into the trap of specifying a particular anaesthetic technique without indicating whether it is important or merely a personal choice. This is, however, not another book on anaesthesia for left big-toe surgery, but a suitable reference work for both those in the field, and those occasionally confronted with oncological problems. The book is reasonably priced, and well presented, plates and diagrams are clear, and most important, it is easy to read.

D.E.F. NEWTON

Books received

We thank the publishers for the following books which may be reviewed in future issues of *Anaesthesia*.

Basics of anesthesia, 2nd edn.
R.K. STOELTING AND R.D. MILLER. Pp. 523. Churchill Livingstone, 1989. £22.50

Talking health: conventional and complementary approaches.
Edited by SIR JAMES WATT AND C. WOOD. Pp. 167. Royal Society of Medicine, 1988. £4.50.

Anaesthesia review 6.
Edited by L. KAUFMAN. Pp. x + 330. Churchill Livingstone, 1989. £17.95.

Year book of anesthesia 1989.
Edited by R.D. MILLER, R.R. KIRBY, G.W. OSTHEIMER, M.F. ROIZEN, R.K. STOELTING. Pp. xi + 369. Year Book Medical, 1989.

Baillière's clinical anaesthesiology—international practice and research, Vol. 2 No. 3, September 1988, Fluid Resuscitation.
Edited by W.J. KOX AND J. GAMBLE. Pp. viii + 433–760. Baillière Tindall, 1988. £18.50.

Pediatric anesthesia, 2nd edn, Vols 1 and 2.
Edited by G.A. GREGORY. Pp. 1388. Churchill Livingstone, 1989. £90.

Anaesthesia, 1990, Volume 45, pages 263–269

The Annual Conference of Linkmen of the Association of Anaesthetists of Great Britain and Ireland, 1989

The President welcomed 192 delegates to this meeting, held at the Taliesin Centre, University College, Swansea, on 13 September 1989. He emphasised that the meeting was intended as a two-way exchange of views and reported that Council had, during the past year, taken note of comments and suggestions made at last year's Conference.

He welcomed the opportunity for informed discussion in order that Council's opinions could be properly founded on the views of the members.

The Bevan Report/Efficiency of theatre services

Dr E. B. Lewis (*Hythe*) began by explaining the background to the Bevan Report, emphasising that, although the document had been submitted to the Minister some months previously, publication was still awaited. He had not seen the definitive version of the Report and therefore the views expressed in his presentation merely represented a personal interpretation of what was likely to be included in the Report.

In response to the report of the National Audit Office that the use of operating departments was grossly inefficient a Steering Group (Chairman, Professor Bevan) had been set up by the Department of Health to consider efficiency of theatre services. Dr Lewis and Dr J. S. M. Zorab had been nominated by the Joint Consultants' Committee to represent anaesthetists' views on the Steering Group. In addition the Association's view, presented by Dr M. M. Burrows, President, and Dr J. E. Charlton, Assistant Honorary Treasurer, had been well received. Many of the recommendations within the Report will agree closely with those in the Association's document, 'Efficiency of Theatre Services'. The Bevan Report was likely to emphasise that throughout the country the level of nonmedical support staff in operating theatres is very variable. The Lewin Report intended operating department assistants (ODAs) to undertake all types of theatre work. In fact, most ODAs work with anaesthetists and thus when, as happens all too frequently after they have been trained, these ODAs leave for more remunerative employment elsewhere, the NHS is deprived of their skilled assistance. This is particularly the case at night where often trainee anaesthetists work without proper assistance. The Bevan Report emphasises this deficiency. Dr Lewis paid tribute to the report of the Association Working Party, 'Assistance for the Anaesthetist', which had played an important part in getting the message across that dedicated, skilled assistance was vital for the safe practice of anaesthesia.

Enquiries revealed that where managers are in post in operating departments many are recruited from the nursing profession. Dr Lewis emphasised that strong management was required and, in particular, proper arrangements needed to be made for duty hours of nurses, particularly in the recovery room. Flexibility should be introduced into the present rigid nursing day to ensure that duty hours corresponded to the time the theatre is actually scheduled to work. These rigid patterns of work often result in cancellation of operating lists due to inadequate numbers of nursing staff. An additional factor is that overtime is not payable to nurses.

The figure of £450 per hour, quoted by the National Audit Office in their report as being the cost of running an operating theatre per day, is to be revised. On the basis of average figures obtained throughout the country, including medical staffing, the figure should be about £151.

Discussion. Dr C. J. Barham (*East Grinstead*) questioned the accuracy of Korner data and provided an example wherein only 6% of operations claimed to have been cancelled were actually cancelled. Dr T. V. Gnanadurai (*Dudley*), reported how in a two-hospital district gross differences of policy within one district occurred, demonstrating the importance of careful selection of those who were to be managers. Dr R. W. Buckland (*Winchester*) encouraged doctors to take part in management and emphasised the importance of accuracy in the recording of data. He noted that the definition of an operating theatre session needed particular care. A clinical director should receive an appropriate NHD allocation and the benefits of proper information technology. Dr Margaret L. Heath (*Lewisham*) spoke about the desirability of reservation of theatres for emergency surgery, stressing that this arrangement must include the availability of surgeons to perform the operations. Dr M. R. Bryson (*Newcastle*) complained about arbitrary timekeeping by surgeons which jeopardised the proper use of staff. He added that in his hospital scheduling emergencies when surgeons were actually available was a major problem.

Dr A. S. Lawrence (*Preston*) stated that he considered the assumption that nurses' hours could be flexible without any attention to their social commitments was now unacceptable. Dr P. V. Scott (*Redditch*) asserted that old-fashioned discipline was required in operating theatres; he advocated the use of the CEPOD definitions of emergency, urgent, scheduled and elective types of operations. Dr A. M. Rollin (*Epsom*) reported that a three-session theatre day was being introduced in her district and wanted to hear of others who had had similar experience. The President asked that she keep the Association informed about this matter. Finally, Dr Lewis agreed with the speakers who had emphasised the importance of definitions of operations, but stated that some doctors ascribed a high degree of urgency to get their cases done. He also agreed that it was impossible for hospitals with only two operating theatres to justify allocating one of them on standby for emergency surgery.

Medical indemnity insurance

Dr J. Wall (Secretary, Medical Defence Union (MDU)) began by expressing his gratitude for being asked to address this topic since the MDU would very much appreciate feedback from members. He reported that Government Ministers have given something close to an undertaking that the NHS Indemnity Scheme will commence on 1 January 1990 but the Treasury had certainly not yet given agreement to this concept. Furthermore, Regional Health Authorities were extremely apprehenisve that from January 1990 they may have to make massive payouts of awards granted in Court particularly as these payments must be made within 15 days. There is a real danger that in order to make such payments, the service in that region would require to be cut.

It was at present still the view of the MDU that a scheme of no-fault compensation would be the best option on a medium to long-term future. No-fault compensation would meet the requirements of brain-damaged patients whose relatives require money from an early date to support a handicapped person. Despite this the country's economy cannot afford to give awards of £500 000 to all brain-damaged patients. NHS indemnity would not tackle this problem and there is the risk that because the claims would be against the Government, their frequency might even increase and the level of settlements remain high. The MDU had offered their special expertise to ensure efficient working of the NHS indemnity scheme.

The medical defence organisations have operated a system whereby they fund the future; monies they take this year are invested against possible future claims. The Government, however, is preparing to 'pay-as-they-go', and does not intend to allocate special funds to provide for this scheme. The MDU had proposed handing over to Government the proportion of their funds which would have paid hospital claims in coming years, for which the liability was already determined. Apparently, the Department of Health had considered this to be a reasonable proposal but the Treasury had not yet agreed.

The defence organisations, at present, sort out the medical merits of a case and have considerable experience in this area but with the new scheme who would sort out merits? A national arrangement would be required to obtain consistency of settlements across the country and to ensure that one health authority did not have to find large sums of money. It was envisaged that doctors would be concerned if a health authority wished to settle by the cheapest option regardless of whether or not negligence were proven. In addition, Dr Wall expressed concern over the possibility that when the fault could be shown to be that of the general practitioner prior to the patient's admission to hospital the health authority would be likely to sue the GP in an endeavour to shed the hospital's liability.

Finally, the MDU would require to give evidence very soon to the Review Body and, at present, would have no other alternative than to suggest two options: one that involved NHS indemnity and the other that did not.

Discussion. Dr A. E. Nichol (*Barnet*) suggested that in effect the introduction of differential subscriptions had apportioned, to some degree, responsibilities between general practitioners and hospital doctors. He also asked whether there was any evidence that, on the advent of NHS indemnity in any form, employers would dictate clinical practice. Dr M. S. Pegg (*Royal Free*) asked what would be the position of junior hospital doctors working with private patients in National Health Service hospitals. Dr K. K. Dutt (*Birmingham*) asked whether subscriptions already paid would be reimbursed for those whose earnings in private practice were restricted to 10% if NHS indemnity were to come in next year. Dr P. Burridge (*Rochdale*) reported that a health authority had already settled a claim unilaterally against a doctor for £25 000 without notifying the doctor concerned. Dr A. Frippon (*Macclesfield*) advocated that members should move from one defence organisation to another in order to acquire the cheapest insurance. Dr A. S. Laurence (*Preston*) asserted that it was impossible for awards to exceed £500 000 since income from such an award would amount to approximately £50 000 a year, greater than that of a National Health Service consultant. Dr M. L. Heath (*Lewisham*) invited comment about no-fault compensation in Sweden which had been very satisfactory in the past and enquired whether this was still the case. Dr J. S. Mason (*Mansfield*) suggested that if differential subscriptions were to become the rule the defence organisations should also advocate differential salaries. Dr R. W. Harris (*Worksop*) asked about cover for doctors who were involved in Red Cross work.

Dr Wall agreed, in answer to these points, that differential subscriptions are divisive but emphasised that general practitioners pay what is assessed by actuaries as being their cost to the defence organisations. On the subject of private practice, he pointed out that some of the highest claims had arisen from incidents in NHS hospitals when nonconsultant staff attended private patients at night in emergencies. There was no decision available from Government about this aspect of hospital work and as yet no decision had been made about 'good samaritan' work. Dr Wall re-emphasised that at present neither the defence organisations nor the Government seem to know what changes are to be introduced or when this might happen. Costs for private practice indemnity would be more fairly related to the income from private practice for individual doctors. When subscriptions are paid in advance the money will be reimbursed by extra duration of the required cover if NHS indemnity is introduced. Dr Wall was convinced that the no-fault compensation scheme in Sweden works quickly and efficiently to the benefit of patients. If NHS indemnity is not introduced, differential salaries will be advocated by the BMA and the defence organisations in their submission to the Review Body.

Pre-anaesthetic check procedures

Professor A. P. Adams said that there is sufficient evidence in the literature that the absence of a proper check of anaesthetic machines constitutes a serious hazard to the safety of patients. The Survey of Anaesthetic Practice records that a substantial number of anaesthetists failed to check their machine. This check is the responsibility of anaesthetists and prompted Council to establish a working party to make recommendations. There are many extant lists; some are too detailed, some are specific to particular machines and some take too long to complete. The Association list is neither designed to be specific to a particular machine or model nor does it supplant any specific test for a particular manufacturer's design. No detailed supplementary equipment is included. The checklist is based on the use of an in-line oxygen analyser. It is desirable that the check be performed by one person and recorded by another (cf. airline practice) but the recommended procedure for recording has not yet been decided: log books for machines or the patient's record are two possibilities.

A draft check list was circulated to Linkmen who were urged to assess its use in anaesthetic practice and to submit comments to the Honorary Secretary.

Honorary Secretary's update

Dr W. L. M. Baird, Honorary Secretary, reported that the Association has continued its policy of publishing reports on important subjects in the form of colour-coded, glossy booklets. The documents published within the 1988/89 session include, *Assistance for the anaesthetist. Consultant trainee relationships. A guide for consultants. Anaesthesia in Ireland — the provision of a safe service* and *Efficiency of theatre services*. This latest document, published jointly by the Association of Anaesthetists, Association of Surgeons and the British Orthopaedic Association in consultation with several other specialist surgical societies had a somewhat difficult gestation period. Great credit must go to Dr J. E. Charlton, secretary to the Working Party, for his patience and diplomatic skills in steering this important document to a satisfactory conclusion.

Some months ago Council of the College of Anaesthetists accepted Council's invitation to form a Joint Working Party to consider the workload of consultant anaesthetists and to review and update the Association's guidelines last published in 1983. The Working Party is making steady progress and it is anticipated that a draft report will be submitted for approval to both Councils before the end of the year. The document will offer guidance to consultant anaesthetists and also to health authority management.

The programme of seminars and workshops has continued to expand throughout the year. Many seminars are now oversubscribed and a waiting-list system has had to be instituted; members are advised to make early application. There will be a modest increase in the registration fees to offset increasing overhead costs. Council is deeply grateful to Dr J. A. W. Wildsmith, Seminars Coordinator, the members of the Organising Committee, Dr W. S. Nimmo, Dr J. F. Nunn, and Mrs L. Ogg, BOC Educational Coordinator.

A new post of Senior Lecturer in Intensive Therapy, to be funded jointly by the Association and the College, has been awarded to the University Department of Anaesthesia at Birmingham under the direction of Professor P. Hutton. The post will be advertised. The financial investment, £60 000 for each of the next 5 years, is clear evidence of the importance that the Association and the College attaches to the need for specific research in intensive care units.

New guidelines to assist members making application for Association research grants, travel grants and other special grants are being prepared. This is in response to the concern expressed by the Education and Research Committee at the declining quality and general standard of some applications received.

Dr Baird drew attention to the future venues for Annual Scientific Meetings and Linkman Conferences: 1991 — Harrogate International Conference and Exhibition Centre; 1992 — Bournemouth International Centre; 1993 — Scottish Exhibition and Conference Centre, Glasgow (combined meeting with Canadian Anaesthetists' Society); 1994 — Brighton Conference Centre. With some reluctance Council has accepted that, with a few exceptions, the Association's increasing requirements in terms of conference and technical exhibition facilities can no longer be accommodated within the traditional university sites. However, Council hopes that the centres of anaesthetic excellence will continue to organise the scientific programmes in rotation. In this respect Council is particularly grateful to the Departments of Anaesthesia at Leeds and Liverpool for agreeing to organise the 1991 and 1992 meetings respectively. Council would welcome your views on this change of policy on future venues for the annual meeting. The intention is that the Winter Scientific Meeting should remain in London.

The response to the pilot study set up by the Joint Association/College Working Party one year ago on reporting of adverse drug reactions associated with anaesthesia has given great cause for concern. During the first 4 months of 1989 only 30 reports were received, whereas 7500 standard CSM yellow cards were returned during the same period. Council has recommended that the pilot study should be extended for a further year at least and that every possible means should be used to publicise the need for anaesthetists to report adverse drug reactions on the new anaesthetic yellow forms. Hospital pharmacists should have a supply and, if not, they can be obtained from the CSM.

Following an enquiry into the death of a female patient from a massive anaphylactoid reaction which occurred at induction of anaesthesia, on the advice of an expert witness, a Sheriff in Aberdeen recommended that Health Boards should consider the introduction of routine tests for patients presenting for elective surgery who had previously received suxamethonium and (or) shown signs of other allergy. The Scottish Home and Health Department asked all Health Boards to seek the views of anaesthetists on this matter. This was clearly an issue with potentially important implications for clinical anaesthetic practice to say nothing of the potential medicolegal implications. The Association therefore set up a Working Party, Chairman, Dr W. S. Nimmo, to examine this whole matter in depth and to make recommendations to Council. The Working Party, having obtained specialist views, including those of the medical defence organisations, had issued an interim report, copies of which were available.

A revised version of the Association's recommended scale of fees for anaesthetists in private practice, to be applicable from January 1990, will become available towards the end of this year.

The Honorary Secretary concluded by thanking Linkmen for their support during the past year in fulfilling the vital role of keeping members appraised of the Association's current activities and in turn informing Council of members' views on these and other matters of concern and interest.

A special tribute was paid to the help received from the previous Honorary Secretary, Dr P. Morris, and from Dr J. E. Charlton, Linkman Coordinator.

Open forum 1

Equipped for anaesthesia

Dr P. V. Scott (*Redditch*) emphasised that anaesthetists need equipment for the provision of safe care of patients and finance for this must be provided by health authorities. If equipment is not provided the health authority must be informed in writing of their vicarious responsibility in the event of a related misadventure. This tactic is successful. The West Midlands Region had determined that when equipping a new operating department the sum of £18 000 per theatre should be allowed for the provision of anaesthetic and monitoring equipment. Dr Scott considered this to be a realistic sum at today's costs. He concluded by appealing to anaesthetists to ensure that patient monitoring equipment was funded from health service sources and not from 'soft' monies.

Dr E. P. Gibbs (*Basildon*) in agreeing with the speaker emphasised the long-standing problem of obtaining health authority funding for replacing obsolescent equipment. The President asserted that the Association's role was to provide sound evidence in support of the need for monitoring in the provision of safe anaesthesia. The Association's document on recommendations for monitoring, which was distributed to health authority managers, has been of great value to members in strengthening their case for the provision of this essential equipment.

Awareness under anaesthesia — can we do better?

Dr J. M. Cundy (*Lewisham*) summarised the information presented at a seminar held at Bedford Square in June 1989. Light levels of anaesthesia are very rarely necessary. Awareness can never be completely eliminated but we must aim to prevent it by administering anaesthetic mixtures of not less than 0.5 MAC of a volatile agent in 66% nitrous oxide. There is a need to ensure that patients who have experienced awareness are identified and, if possible, offered an explanation. The severe psychological trauma which results from awareness during anesthesia requires careful counselling, preferably by an anaesthetist who is skilled in this aspect of patient care. Reference to a psychiatric outpatient clinic is not an appropriate way of dealing with this problem.

Dr Cundy advocated that every patient should be seen postoperatively, with particular attention to patients after Caesarean section under general anaesthesia, where the risk of awareness is greatest. Careful records should be kept, including the completion of a questionnaire by the patient following discharge from hospital, to enable data for outcome audit to be collected and collated. A pilot scheme to audit the outcome for all patients after general anaesthesia for Caesarean section, which will be set up in the South East Thames region, is to be coordinated by Dr Cundy. It is hoped that this pilot scheme will indicate the potential for wider studies of outcome after anaesthesia in other surgical specialties.

Standards of locum consultants

Dr M. R. Bryson (*Newcastle upon Tyne*) was concerned that applicants for locum consultant posts frequently did not satisfy the criteria of the College of Anaesthetists. In many cases the candidate had not completed higher professional training while in some instances the applicant was not even in possession of the FCAnaes diploma. There was evidence that these applicants are accepted in some hospitals and that they subsequently apply for substantive consultant appointments claiming that this can be justified by already having satisfactorily carried out the duties of a locum consultant.

Whilst recognising the pressures on a short-staffed department where the consultants already bear a heavy clinical workload, one has to remember that a locum consultant carries all the responsibilities, and privileges, of a substantive post. Dr Bryson was strongly of the opinion that consultant standards and status should be maintained. When an applicant does not fulfil the College criteria, a locum consultant appointment should not be made. A practical alternative might be to offer an appointment at an appropriate subconsultant grade.

In discussion Dr A. S. Lawrence (*Preston*) agreed that there was a real danger of unaccredited anaesthetists 'falling into' locum consultant posts because appropriately trained applicants could not be found. An instance was cited by another Linkman where an inadequately trained anaesthetist, holding only the DA, had applied for admitting rights at a private hospital on the strength of having occupied a locum consultant post within the health service. Dr P. V. Scott (*Redditch*) affirmed that when the services of an appropriately qualified locum consultant cannot be obtained the elective clinical workload must be cut back. Dr J. Edmonds-Seal (*Oxford*) pointed out that health authorities should apply the same standards to both locum and substantive consultant appointments. A proper advisory appointments committee should be convened. Although this is often omitted when appointing a locum, there certainly should be no question of an inappropriately trained applicant being appointed by default to a substantive consultant post.

Advice for chronically ill or handicapped anaesthetists

Dr C. R. Harvey (*Truro*) explained that his department had recently lost the services of a young consultant who was forced into premature retirement on the grounds of ill health due to a chronic debilitating disease. Statistically it is likely that at any one time there will be a colleague in anaesthesia somewhere in the country who is afflicted by a disease which will threaten their career. Chronic illness brings tragic problems for both the individual and the department; the disability may strike at any time and take many forms. Anaesthesia is a practical specialty and so a condition which may be little more than a hindrance to a physician or a psychiatrist can render an anaesthetist unable to practise. Conflicting pressures arise. For the individual the greatest difficulty is to accept the fact that eventually they will be unable to work; the time when this inevitability becomes a reality can be a very difficult decision and often occurs when financial commitments are at a maximum. At the same time the chairman of the division has a responsibility to ensure safe anaesthetic practice and yet will wish to support a well-liked and respected colleague for as long as possible. By offering alternative sessions some departments will be better able to absorb the workload than others, but a small department with a heavy workload and relative understaffing cannot carry a 'passenger'.

Dr Harvey was of the opinion that in these circumstances independent advice from an outside agency, such as the Association of Anaesthetists, would be invaluable. He proposed that the Association should give consideration to acting in a supportive role to provide: (i) a base for discussions and consultations which could offer advice on practical matters such as the contract, pension schemes etc. (ii) independent advice on appropriate assistance in the operating department (or equivalent). (iii) a counselling service to offer career advice to the debilitated anaesthetist. (iv) independent advice in support of the divisional chairman. Independent advice from representatives of the Association would be of much greater practical value than that offered by the traditional means.

The President thanked Dr Harvey for his very constructive presentation. The Association will give careful consideration to his suggestions.

Distinction and meritorious service awards

Professor Sir J. G. Robson, Chairman, National Advisory Committee on Distinction and Meritorious Service Awards, defined distinction as 'service over and above the call of duty in the National Health Service'. This service may be related to care of patients, the development and organisation of a hospital or department, research and development in medicine or 'bearing the heat and burden of the day' in clinical work. All consultants in the hospital service and in community medicine are eligible for awards. Judgement about the worthiness for an award varies with the type of work undertaken. Standards which are applied to a busy consultant in a small district general hospital would not necessarily be the same as those applied to a professor in a postgraduate institution.

On the inception of the system, it was determined that one-third of hospital consultants should hold awards. The limited consultative machinery had developed over the years and now the Committee, of which Sir Gordon is Chairman, consisted of representatives of the Presidents of Colleges and Deans of Faculties, the CCSC, the Scottish Awards Subcommittee, the dental surgeons, and community physicians together with a representative from the committee of vice-chancellors and principals and from the Medical Research Council. The recent Government White Paper adds a representative of senior administrative staff. The function of the Committee is to advise the Secretaries of State about the distribution of these awards after discussion with regional committees. The regional C award committees are appointed from regional subcommittees of the CCSC. The higher award committees (B and A awards) are selected from higher award holders within the region by the chairman of the central committees. A+ awards are made by the central committee. Advice and special pleading is heard from representatives of the Colleges, Faculties, Vice-chancellors and Principals and Community Medicine together with special advice from professional associations and from individual consultants. In addition there is now a special review system for consultants who have not received an award after 15 years' service.

At present, throughout the UK, 35% consultants hold some award. Regional differences do exist, for example, North-East Thames has 39% consultants with awards, whereas the West Midlands has 33%. This is because there are many teaching hospitals in the North-East Thames region and these act as magnets for talented individuals who naturally receive awards. Anaesthesia is the largest single specialty and, as a result of anaesthetists extending their clinical role into intensive care, obstetrics, pain relief etc. there has been an increase in the number of awards given to the specialty. However, the national committee works on the principle that no specialty is more meritorious by definition than any other. Furthermore the committee recognises that the distinction award system must not be used to compensate for bad manpower planning. Women have half the expected rate of award holders, partly because their duration of service is shorter than that of men.

In conclusion, Professor Robson outlined some unsatisfactory examples of citations which had been submitted to the Committee. These served to emphasise the importance of the original definition of the word 'distinction'!

Discussion. Dr M. L. Heath (*Lewisham*) mentioned that lists from her hospital, which previously used to include all medical staff, now only identified non award holders and she was worried about the breach of confidentiality in this new system. Sir Gordon replied that confidentiality is not really an important issue; any system which worked well had his full support. The questionnaire had been introduced for people without awards despite 15 years in the health service and this would obviate some of the difficulties. Sir Gordon commented that he would like to see every award notified on hospital notice boards!

Dr W. P. Clarkson (*Exeter*) asked about the relevance of the statement in the White Paper that no award should be given within 3 years of retirement. Sir Gordon replied that strong reasons have always been a prerequisite for an award to be made toward the end of an individual's career. This practice used to be common but now was very much a rarity, although the whole matter was not always so clear-cut as the White Paper might suggest. It should be remembered that awards are really made retrospectively on the basis of achievement. The suggestion in the White Paper that a 5-year review might be implemented for award holders was also full of problems. Any decrease in an award would amount to a disciplinary action, and the resultant difficulties with pension calculations were such that the Department of Health is extremely nervous about this suggestion. The White Paper also proposed that a C award must be made before a B award can be granted. Sir Gordon did not support this concept, for although in general this has been the case, there have been very occasional exceptions to this general principle which have been entirely justifiable.

Dr J. A. T. Duncan (*Fife*) saw advantage in abandoning the merit award system in favour of seniority payments, as applied in general practice. He believed that in this way general managers, as members of the awards committees, would be denied an opportunity to exploit the awards system. Sir Gordon replied that seniority payments did not offer a stimulus. In his opinion general managers do not wish to take over the merit award system. He affirmed that the Hospital Consultants' and Specialists' Association want to abandon the system, but members should realise that if one annual review body were to introduce this change all consultants would be regarded as having a top salary equivalent to an A+ award holder. There would then be no further salary increases and everyone would be much worse off within 2 to 3 years. The Civil Service had tried to introduce a seniority payment system, but this had proved to be miserably unsuccessful, heavily bureaucratic and extremely difficult to implement. He also pointed out that the merit award system costs very little indeed to administer! Dr G. T. Whitfield (*Scarborough*) asserted that there was widespread disquiet in the profession with the merit award system. Both Sir Gordon and the President suggested that this was not in accord with the facts.

Dr B. W. Perriss (*Exeter*) asked about the extent of the involvement of managers. Sir Gordon replied that there would be no substantial change since management already influenced the decisions of merit award committees. It is likely that two to three representatives of management would sit on the regional awards committee. The President reiterated the view that the system adminstered by, and for, the profession was appropriate; the profession must predominate in the actual allocation of awards.

Open forum 2

Manpower, workload and the GPT Guide: how well do we cope?

Dr J. Chambers (*Wirral*) referred to the General Professional Training Guide of the College of Anaesthetists which states that juniors are trainees and must not be treated merely as pairs of hands. They should have at least three teaching sessions in the operating room per week. He had surveyed 255 College tutors about their achievement of this directive and some 75% had responded. It appeared that 17% tutors could implement the recommendations part of the time and that 83% achieved the desired standard most of the time. Further analysis of the workload of trainee anaesthetists showed that a substantial number worked with consultant surgeons and that, on this basis alone, 68 new consultant anaesthetist posts should be created (September 1988 figures).

Medical audit — how and what?

Dr D. P. Cartwright (*Derby*) feared that the profession was being 'steam-rollered' into audit partly as a result of the White Paper and he sought guidance for his department (as did Dr G. T. Whitfield (*Scarborough*)).

Medical audit — anaesthetic records

Dr G. T. Whitfield (*Scarborough*) asked what details should be collected, what information is relevant and how would this benefit either the profession or patients? These questions required to be considered at a national level otherwise different interpretations of the problem would be made throughout the country.

In discussion Dr J. S. Cundy (*Lewisham*) emphasised the need for outcome audit and used as an example the incidence of postoperative vomiting and how this should be identified and avoided. Dr A. S. Lawrence (*Preston*) saw audit as a method to eliminate interdisciplinary mismanagement and to encourage joint meetings. Dr J. N. Lunn (*Cardiff*) advocated a system of audit designed to solve local problems and emphasised that data relevant to that end only should be collected. The College of Anaesthetists had now set up an audit committee (chairman, Professor J. Norman) and some general advice was anticipated from the Department of Health which would emphasise the need for the medical profession to undertake medical audit.

The President emphasised the importance of medical audit and noted whilst management might wish to emphasise the cheapest drug, treatment or operation, it was up to the medical profession to identify that which was best. He agreed that outcome audit is one appropriate technique to ensure a high quality of care. In answering Dr P. V. Scott (*Redditch*) he acknowledged that audit systems are expensive but reaffirmed that the Department of Health is making money available for this purpose through the College.

Anaesthetic nurses: training and career structure

Dr D. B. Bennie (*Dumfries*) spoke about the problems associated with the career structure and training of anaesthetic nurses. He advocated amalagamation of the courses not with surgical (operating theatre) but with recovery room courses. The President emphasised that Council's opinion was that anaesthetists should have supporting staff solely responsible to them, and revealed by a show of hands that this was the majority view, and practice, of the representatives at the Conference. Dr J. Edmonds-Seal (*Oxford*) suggested that members should encourage the idea that anaesthesia was a basic core service (White Paper definition) to a hospital. If this were done it would be essential to include anaesthetic nurses in that organisation and thereby remove this group from the influence and direction of nursing management.

Cardiac arrest management training: dental GA teams

Dr P. Burridge (*Rochdale*) outlined the need for resuscitation teams in hospital to be trained particularly, but not solely, in relation to anaesthesia in dental surgeries. He advocated the use of the advanced life-support system used by the American Heart Association, the Royal College of Physicians and the Royal College of Surgeons. Dr J. Freshwater (*Airdrie*) agreed but pointed out that the recent publicity about a death in the dental chair and the associated suggestion that monitoring should be more comprehensive in dental surgeries had had the effect of increasing the referral rate to hospitals for patients requiring dental anaesthesia. This had substantial resource implications. A general discussion then took place about various local solutions to these problems, the problem of training and the adequacy or otherwise of monitoring facilities in dental surgeries. Further contributions to this discussion were made by Dr P. Cartwright (*Derby*), Dr R. C. Brookes (*Croydon*), Dr D. P. Winder (*Hull*), and Dr R. W.Buckland (*Winchester*).

Junior anaesthetic staffing: the 1:3 roster

Dr S. K. Hepton (*Romford*) stated that her district management had announced that no junior was to work emergency night duties more frequently than 1 in 3, or preferably 1 in 4. Furthermore juniors would not be permitted to work unsupervised for more than 24 hours continuously, or more than a total of 72 hours per week. She outlined the particular problems which this posed for her hospital in respect of weekend duties. Dr Hepton questioned whether some approach should be made to the Department of Health to allow staff grade personnel to undertake emergency work. The President noted the points and undertook that Council would consider these matters.

Control of substances hazardous to health regulations — how do we respond?

Dr P. Bickford-Smith (*Bradford*) reminded Conference that the Health and Safety Executive regulations which govern the 'Control of Substances Hazardous to Health' (COSHH), although originally intended for industry, will apply to NHS hospitals with effect from October 1989.

The Department of Occupational Health at Bradford Royal Infirmary has requested a list of hazardous substances used in anaesthesia, a list of exposed personnel and an assessment of exposure risks to health in order that a plan of action to control and reduce exposure to hazardous substances may be made.

The regulations put a duty on employers to ensure that exposure levels of individual employees are monitored and maintained below acceptable limits, but the limits for anaesthetic agents are not defined. The introduction of scavenging systems is presumed to have resulted in a diminution of pollution levels within the operating theatre, but a recent survey of nitrous oxide exposure levels within the Bradford district had revealed marked variation between members of staff. Recovery areas are not usually scavenged and therefore may constitute a significant source of pollution — 'what goes in must come out'.

Dr Bickford-Smith suggested that, since COSHH had recommended consultation with appropriate trade associations on this matter, perhaps the Association should make guidelines available to members. He suggested that, although previously estimated to be insignificant, perhaps consideration should now be given to the environmental effects of 3000 tonnes of nitrous oxide plus the large volume of chlorofluorocarbons (CFCs) (12 500 gallons) which are currently vented into the atmosphere each year.

The Government's White Paper — 'Working for Patients'

Mr D. Nichol CBE (Chief Executive, National Health Service) wished to review some of the points in the White Paper and in particular to stress the potential advantages for patients and staff therein. Since anaesthesia was the largest single specialty in the health service, he acknowledged the importance of anaesthetists' potential influence on events.

The background to the White Paper was the perception that there was a need for change in management of the Health Service. This arose because of increased demand by the public, increased expectancy and a decreased threshold for a perceived need for care and treatment. The problem was accentuated by the fact that this coincided with advances in medical technology and the increasing age of the population as a whole. The Health Service is, however, recognised to be effective and efficient in its best parts despite the acknowledgment that there are imperfections. Widespread ignorance about costs of treatment, and in particular costs in relation to the effectiveness of treatment, were also apparent. Mr Nichol believed that the service was overdirected at the centre, overadministered and undermanaged. Thus the Government undertook a review, recognising implicitly that the solution was not merely a prescription of more money, since that in itself would not correct the underlying deficiencies of the service.

The role of the district health authority had been, in the past, both to manage hospitals and to match this with the perceived health needs of the community. This had led to conflict. Managers were too close to local interests and their decisions had not necessarily been made in the best interests of that community. The decision had therefore been made to separate the purchaser and the provider. Money was now to follow the patient. Districts will need to study health needs, target and cost the provisions that they intend to make and negotiate contracts to deliver the solution to those needs. They will no longer be so intimately involved in the running of hospitals. This contract culture will affect both the selfgoverning hospitals and the remaining directly managed hospitals in a similar fashion. However, the district health authority will be able to leave the day-to-day running of hospitals to managers and less interference is anticipated.

These contracts will expose hospitals to competition and will specify a quality of provision. There will now be an incentive to offer a better quality service and thus in the future the so-called 'efficiency trap' may be avoided. Districts should see that there are opportunities for the philosophy of the White Paper to be exploited to the benefit of the population which they are supposed to serve.

These ideas will be tested well into the 1990s as part of an evolutionary pattern of change: there is to be no sudden cataclysmic alteration.

Selfgoverning hospitals had generated three myths: they will opt out from the National Health Service, they will only offer specialist services and their prime purpose will be to generate income. Mr Nichol emphasised that the idea of selfgoverning was part of the decision to encourage peripheral decision-making rather than central bureaucracy. The selfgoverning hospital would be a natural devlopment of this policy, being within the National Health Service but with freedom increased. It will be possible for them to borrow, to realise capital on property and to employ under locally agreed policies. They have, however, specific duties and responsibilities. Flexibility in pay was unlikely to lead to great variations in remuneration throughout the country. A hospital with selfgoverning status will continue to provide postgraduate training and the core services required by the district. The core services, to be defined by the district and not by the selfgoverning hospital, will include both acute and community services in addition to services for the elderly and mentally handicapped. Primary care will be closer to secondary care. Districts will have to liaise closely with general practitioners to ensure that local needs are fully understood and met.

The consultant contract will be managed by districts acting as agents for regional health authorities. The work of consultants is recognised to be crucial in hospitals but they cannot continue to act as autonomous individuals. Managers and consultants must work together in partnership and conciliation by a third party may be required in the event that confrontation occurs.

Mr Nichol concluded by stating that he regarded the White Paper as a piece of permissive legislation, dependent on iterative dialogue to enable change at 'a pace which feels right'. He emphasised that managers wish to learn by experience and they want to match this with a need for scientific experiment as perceived by consultants. He reiterated the view that mutual respect was an essential feature of making the White Paper work.

The President expressed gratitude to the speakers for their valuable presentations. He thanked Linkmen for their constructive comments and their continuing support of the Association in maintaining vital links between the members and Council. The meeting was closed.

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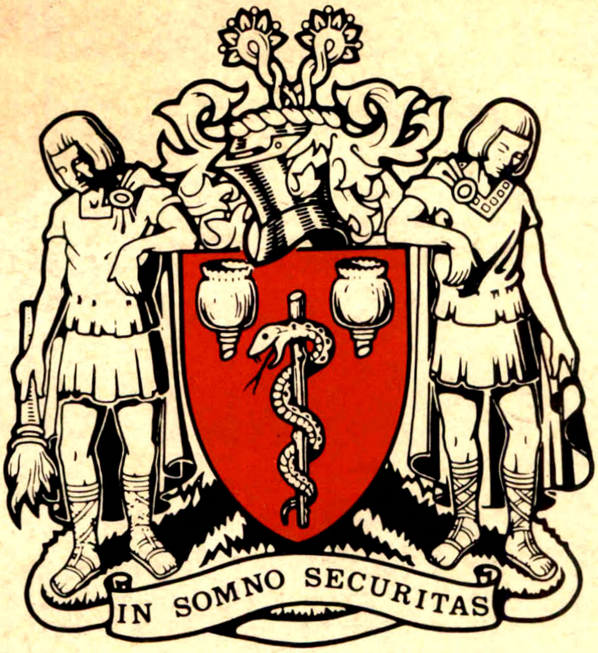

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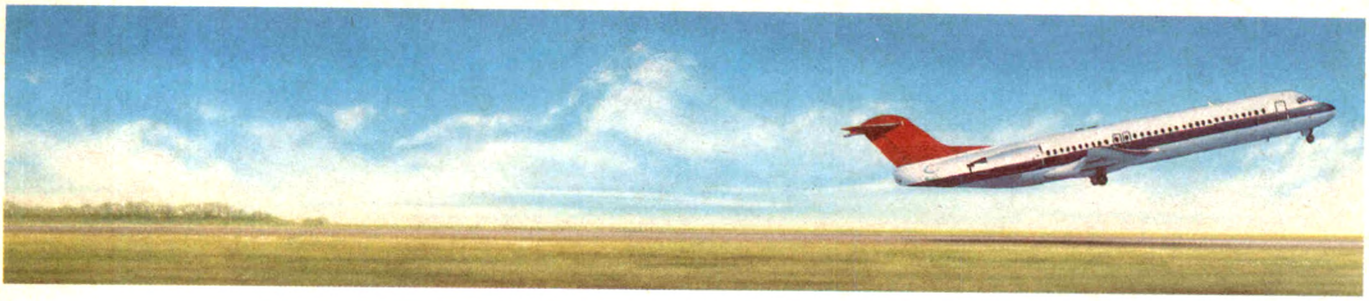

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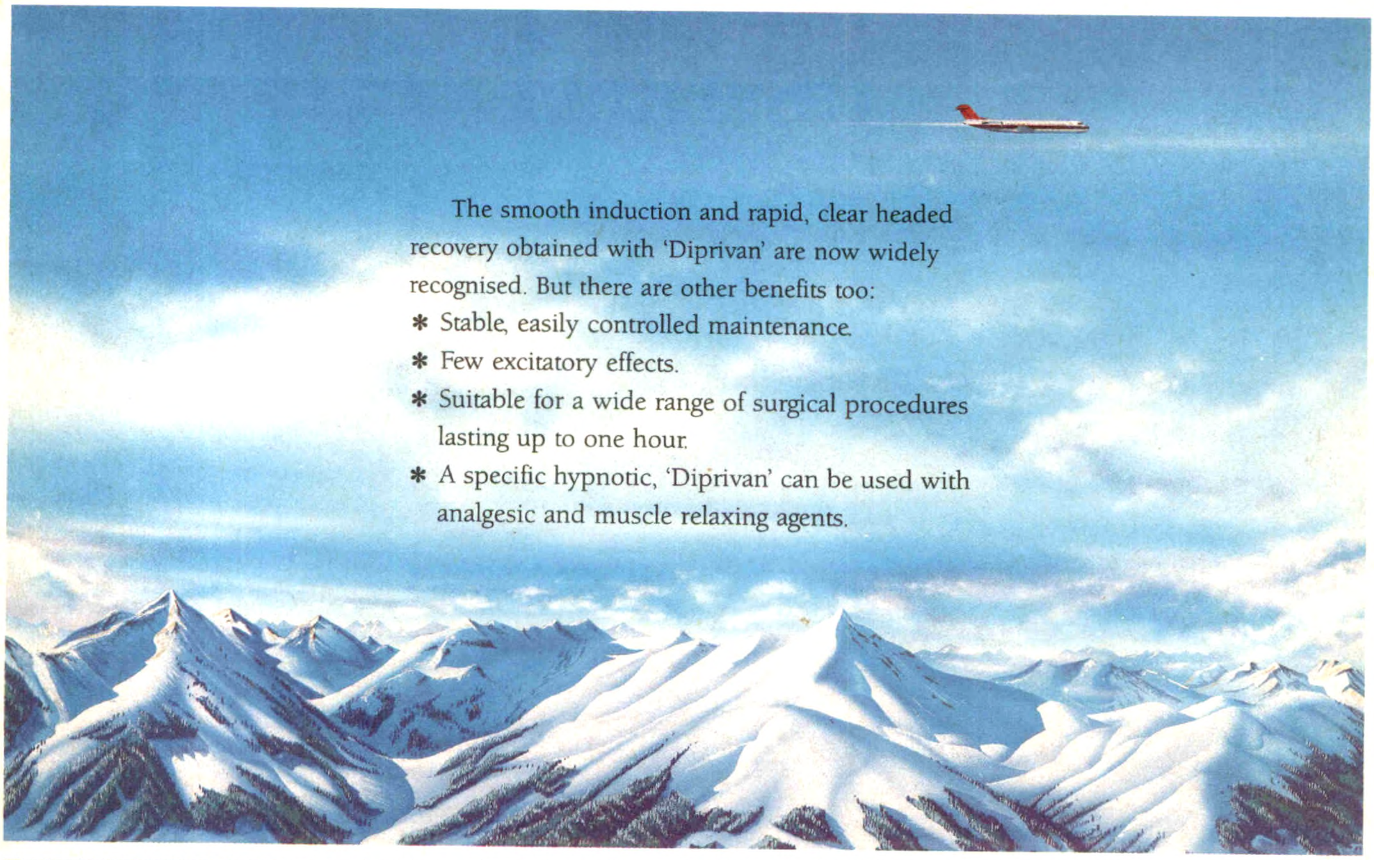

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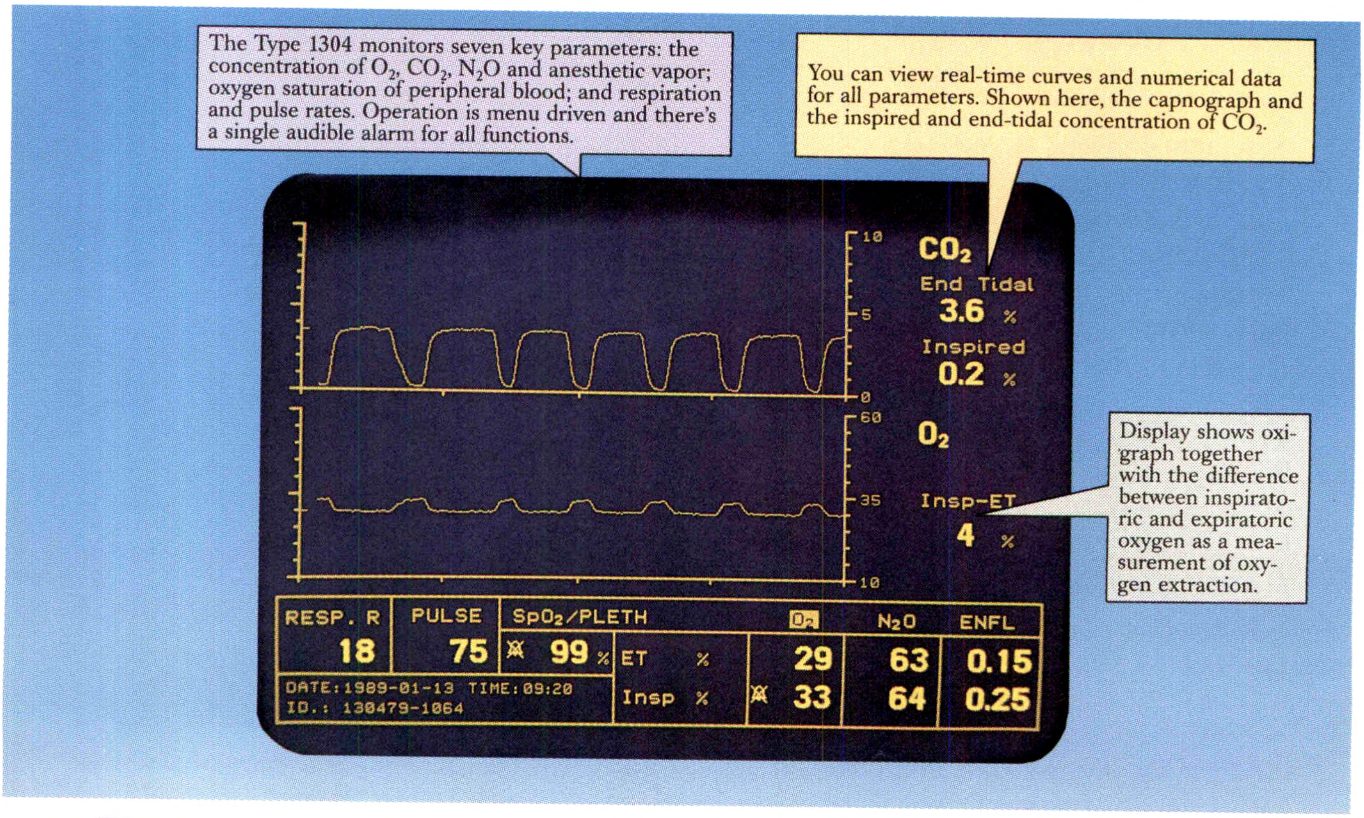

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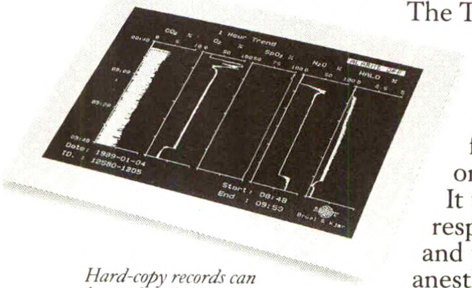

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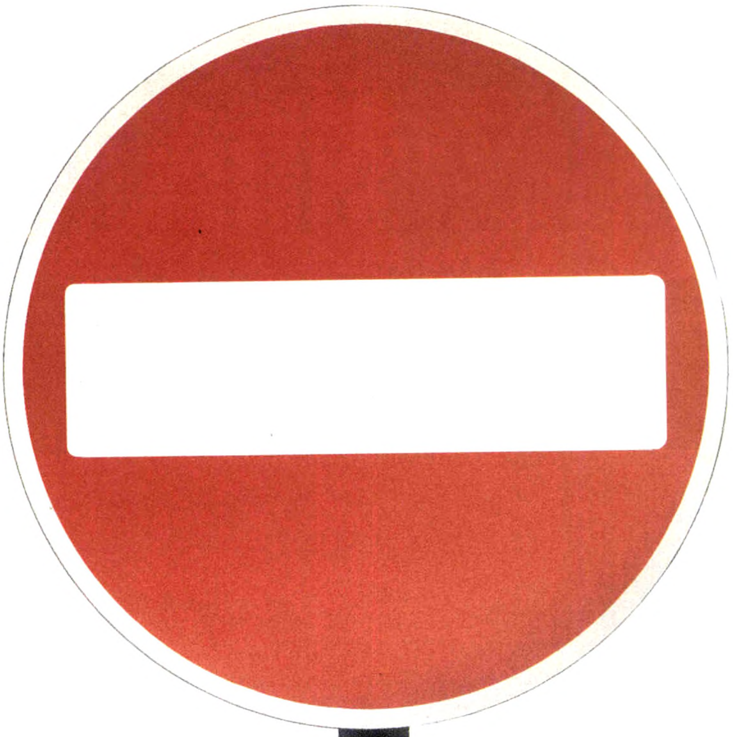

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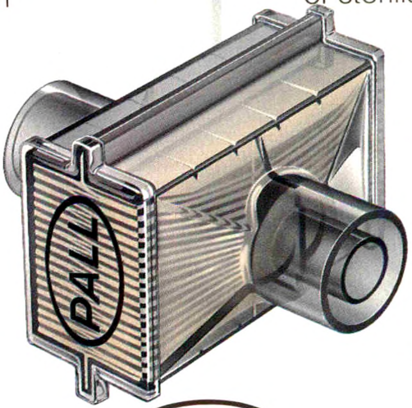

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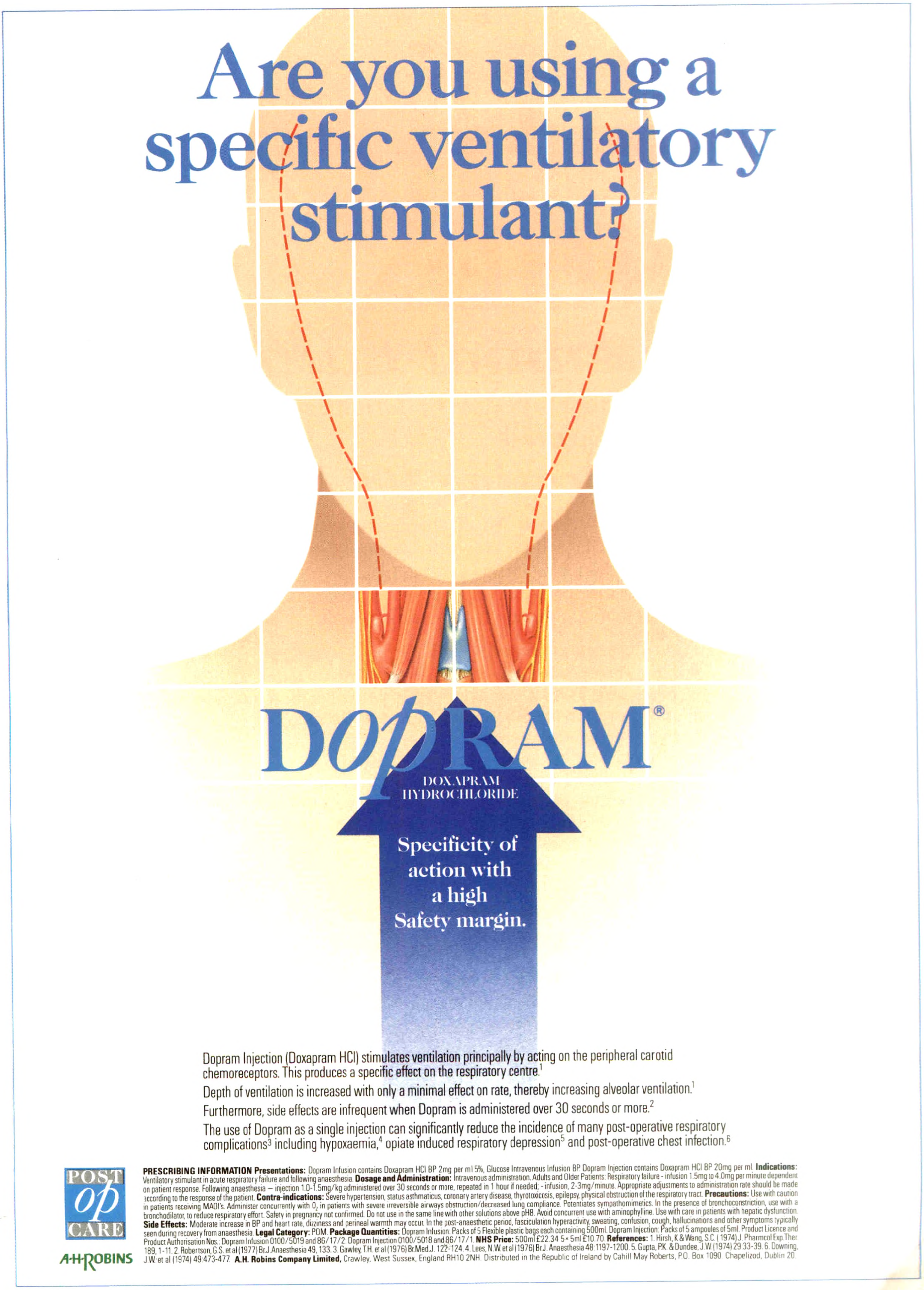

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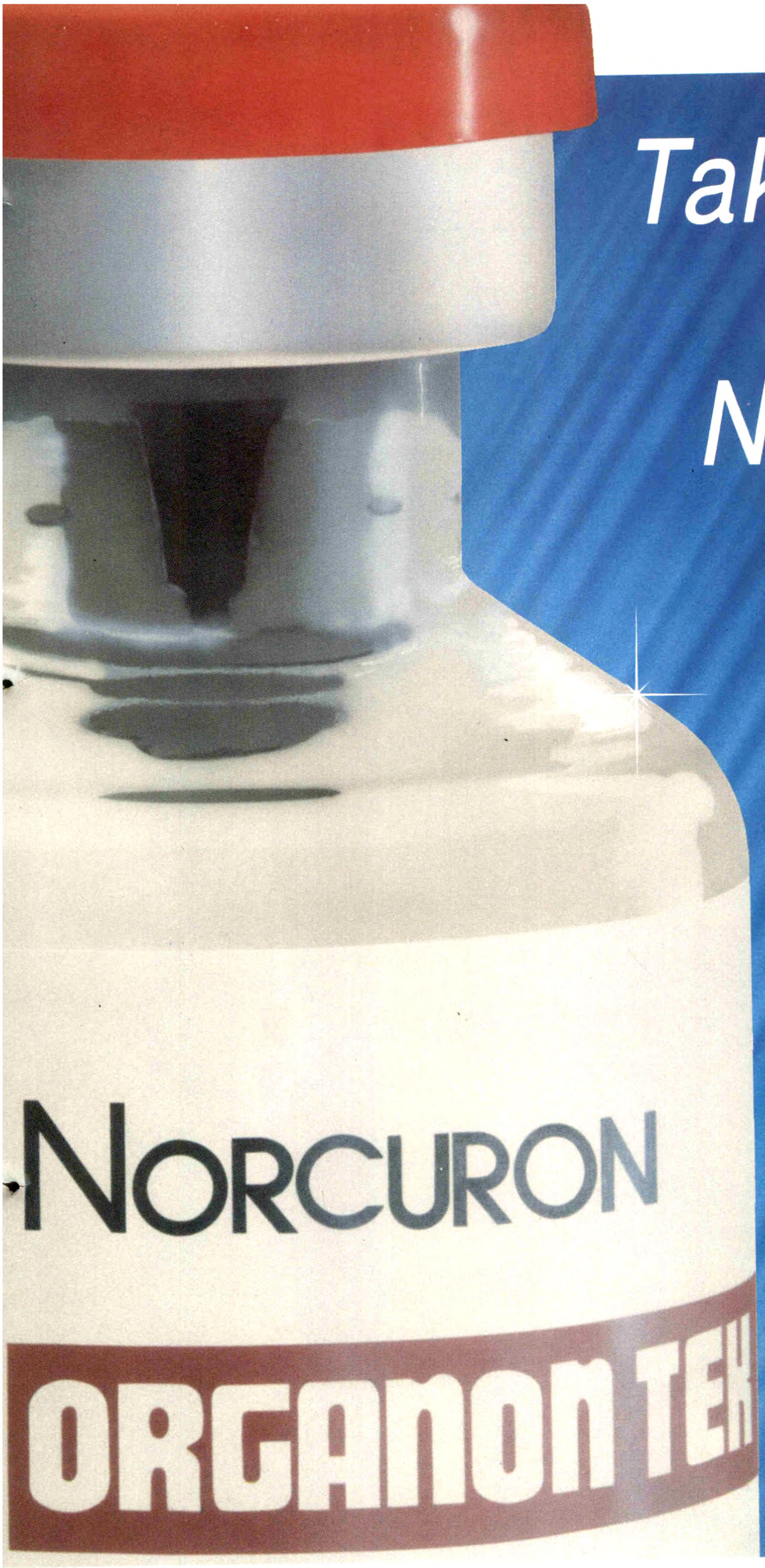

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Anaesthesia, 1990, Volume 45, pages 271–272

Editorial

Clinical research in anaesthesia

Past accomplishments and a future horizon

The purpose of clinical research is to understand and ultimately to resolve clinical problems. The important problems of anaesthesia relate to the three broad objectives of anaesthetic care that were enunciated by Henry K. Beecher about 35 years ago: the facilitation of surgical therapy, the assurance of patient safety and the provision of patient comfort.[1] Clinical research conducted by anaesthetists and others over the past four or five decades has explored a broad range of individual problems that may be encountered within these aims during the period of anaesthesia. The outgrowths of this research have been new knowledge and, in addition, new drugs, monitors and management techniques which now enable skilled anaesthetists to prevent or alleviate most of these clinical problems and thereby meet Beecher's objectives for a wide spectrum of surgical patients.

It should be recognised that the considerable advances made in the resolution of the problems of safety during the period of anaesthesia have not been matched by developments with respect to safety in the subsequent phase of surgical care, the first postoperative week. This is evident in an examination of past and present rates of comparable respiratory, cardiac and neurological complications associated with each of these periods. Pulmonary aspiration and atelectasis have become infrequent events during anaesthesia but atelectasis and pneumonia remain quite common complications of the first few days after operation and appear, for example, in 25% or more of patients after upper abdominal surgery.[2] Myocardial infarction during the course of anaesthesia and noncardiac surgery has almost disappeared as a risk today, but myocardial infarction during the subsequent week continues as a notable hazard. It occurs in 5–10% of patients with known cardiac disease[3] and accounts for a substantial proportion of all cases of myocardial infarction, perhaps as great as 6%.[4] Delirium upon emergence from anaesthesia is only occasionally a problem today but delayed delirium or 'interval psychosis' remains an important and unabated complication of the second to fourth days after operation; this develops in about 12% of patients over 65 years and 35% of those above 80[5] and carries with it the risk of long-term cognitive impairment.[6] Stroke and other types of brain damage are now extremely rare during anaesthesia, but stroke still occurs, albeit infrequently, during the first week after a variety of surgical procedures.[7] These and other differences mean that whereas the period of anaesthesia has become a remarkably safe component of the overall surgical experience, the first postoperative week remains quite risky for many patients.

This disparity in advances with respect to the safety of anaesthesia and the postsurgical period can be traced to the relative amount of research and development of knowledge in each of these areas. Intense research activity, on the one hand, has generated a wealth of information about the factors that precipitate pulmonary aspiration, atelectasis, respiratory failure, shock, cardiac arrest, myocardial infarction, brain damage and delirium during and (or) immediately after anaesthesia. We, armed with this knowledge, have developed means of effective prevention of these complications most of the time. A comparatively small amount of investigation, on the other hand, has left us with only a partial understanding of the genesis of atelectasis, pneumonia, and certain forms of respiratory failure which appear in the first week after operation, and almost no scientifically valid information about the particular factors that trigger myocardial infarction, stroke or delirium after operation. To the extent that we lack firm knowledge about the genesis of these postoperative complications, we are unable to formulate reliable methods of prevention. For example, since we do not yet know exactly what precipitates the typical myocardial infarction in the first week after noncardiac surgery, we have no sound idea about how to prevent it, speculation notwithstanding.

The explanation for the relative scarcity of investigation into certain hazards of the postoperative period probably lies with the traditional academic orientations of various specialty groups. Surgeons, who have studied postoperative complications, have usually concentrated on those that are readily recognised as directly linked to the surgical procedure itself such as wound complications, shock and infection, and have tended to ignore those that seemed either anatomically remote from the procedure or partly 'medical' in origin, such as myocardial infarction, delirium and stroke. Anaesthetists, for the most part, have focused on those problems that arise in the immediate peri-anaesthetic period and have overlooked those that develop afterwards, even though the latter are sometimes attributed, rather loosely, to 'the anaesthetic'. Physicians have usually regarded postoperative hazards as 'surgical' or 'anaesthetic' in nature and have almost completely ignored them in their academic pursuits. The serious study of several important problems of the postoperative period would appear to have fallen as a result through cracks in the academe.

Perhaps it is time for clinical researchers in anaesthesia to extend Beecher's objective of patient safety and address themselves to the solution of the important hazards of the first postoperative week. Such an extension of Beecher would not be without precedent since anaesthetic researchers are already advancing knowledge in the areas of patient comfort and intensive care support during the postsurgical period. Some may question the involvement of anaesthetists in the study of postoperative complications, and argue that these problems have not been traditional areas of anaesthetic interest or responsibility, but the plain fact is that the traditional interests of all specialty groups, anaesthetists, surgeons and physicians alike, have left the study of some of these problems in a kind of 'no man's land'

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impasse. Some sort of break with tradition will be needed if these complications are to be understood and ways found to prevent them. Some, at least, of the unsolved complications undoubtedly arise from responses to trauma, pain and (or) drugs and since their prevention will probably require manipulation or control of such responses, who better than anaesthetists to make the break and push forward academic development in this rather badly neglected medical field?

Over the past four or five decades, the scope of surgery and the comfort and safety of anaesthesia have improved greatly, in large part due to the success of anaesthetic research. If there are to be further substantive gains in the overall safety of surgical therapy, most will likely come from a concerted effort by researchers to understand and find ways to prevent the several serious complications of the first postoperative week. These problems, although difficult, are undoubtedly soluble, like many faced by anaesthetic researchers in the past. Clinical investigators with an anaesthetic perspective should take up the challenge!

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Anaesthesia, 1990, Volume 45, pages 273–278

Haemodynamic and neurohumoral effects of xenon anaesthesia

A comparison with nitrous oxide

F. BOOMSMA, J. RUPREHT, A. J. MAN IN 'T VELD, F. H. DE JONG, M. DZOLJIC AND B. LACHMANN

Summary

Thirty-two patients were randomly allocated to be anaesthetised either with nitrous oxide or xenon. Those who received nitrous oxide required significantly more fentanyl peroperatively. Arterial blood pressure and heart rate were adequately controlled during surgery in both groups. Plasma noradrenaline and prolactin increased peroperatively in both groups, but plasma adrenaline and cortisol, which increased in the nitrous oxide group, did not change in the xenon group. Growth hormone was below control in those given xenon, but not in the nitrous oxide group, while dopamine remained unchanged in both groups. Postoperative plasma concentrations of noradrenaline, adrenaline, cortisol and prolactin (in both groups) and dopamine (in the nitrous oxide group) were elevated, and slowly returned to control. No differences were seen between the two gases in effects on plasma sodium and potassium. Xenon, because of its favourable haemodynamic, neurohumoral and antinociceptive properties, deserves a more prominent place in anaesthetic practice than it has so far occupied.

Key words

Anaesthetic gases; nitrous oxide, xenon.
Sympathetic nervous system; adrenaline, noradrenaline, dopamine.
Hormones; corticosteroid, growth hormone, prolactin.

Cyclopropane is now little used and nitrous oxide (N_2O), apart from its lack of potency, remains as the anaesthetic agent closest to perfection. Its virtues were overshadowed fleetingly when the effects on bone marrow were described, but this action is now well understood and can be controlled by administration of folinic acid.[1] Other substances known to share the qualities of N_2O are xenon (Xe) and krypton (Kr). Xenon* was evaluated as an anaesthetic agent,[2] but has since remained of theoretical rather than of practical interest.

Xe is nonexplosive, and although under special conditions it can form chemical compounds with very reactive elements, such as oxygen and fluorine, it is extremely unlikely that it participates in any chemical reaction when used as an anaesthetic,[3] but it is still possible that Xe may be involved in some biochemical reactions.

The water–gas partition coefficient of Xe, 0.085, is impressively low even when compared to cyclopropane and N_2O (0.21 and 0.47 respectively).[4] This valuable anaesthetic property of Xe is further enhanced by its antinociceptive effect, which is greater than that of N_2O; it has a MAC value of 71%,[5] which has been confirmed in other studies.[6] It was also found that Xe-anaesthesia was remarkably free of haemodynamic side effects and caused no diminution in regional blood flow of various organs.[7] These recent data confirm an earlier description of Xe as somewhat superior to N_2O.[8] The view, prevalent at that time, that the anaesthetic properties of Xe were not so superior as to justify the higher costs, must now be revised. A substantial decrease in the price of Xe together with availability of closed anaesthesia systems have now brought this gas within comfortable reach for routine use in anaesthesia.

The effectiveness of Xe as an anaesthetic is well documented, but there is need for more data about its interference with haemodynamic and biochemical effects in man. Xe should be compared with N_2O in the same clinical setting for appropriate evaluation. Thirty-two patients were randomly assigned to be anaesthetised with either N_2O or Xe in the present comparative study. The anaesthetic pro-

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*One litre of 99.997% pure xenon costs approximately £7.60. The first hour's anaesthesia with xenon, in a 70-kg adult using a closed system with a volume of 3 litres, would cost approximately £61 and each subsequent hour £21.

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cedure was conducted in such a way that the need for analgesic agents could be used as a parameter for comparison of the two gases. Unfortunately, in the clinical setting, one MAC of Xe (70%) can only be compared with 0.7 MAC of N_2O (70%).

Methods

Thirty-two adult patients, ASA1 or 2, who had gynaecological, plastic or orthopaedic surgery, gave written informed consent to be anaesthetised with either N_2O or Xe, both 70% in a mixture with 30% oxygen. The study was approved by the hospital's ethics committee. Exclusion criteria included gross obesity, expected blood loss of more than 0.5 litre, dehydration and hypertension. Care was taken that the patients were well matched in all respects. Patient data are summarised in Table 1.

No premedication was given. Methyl-atropine bromide (0.002 mg/kg intravenously) and 500 ml Ringer's lactate solution preceded induction of anaesthesia, with thiopentone (2.5–5 mg/kg) and 0.1 mg fentanyl. Tracheal intubation was facilitated by 0.1 mg/kg pancuronium, and after washing out the patient's alveolar nitrogen the anaesthetic was administered in a closed system in combination with a Servo ventilator 900 C. This combination was adapted especially for this study by Siemens-Elema (Sweden).

Maintenance of anaesthesia was with either Xe or N_2O, both 70%. The anaesthetist was unaware of the identity of the anaesthetic. The operation started as soon as wash-in of the gas was accomplished. Incremental doses of fentanyl 0.1 mg were administered whenever the arterial blood pressure increased more than 20% as compared to the pre-anaesthesia value. Ringer's lactate solution was infused at the rate of 2 ml/kg/hour. End-tidal CO_2 was kept at 4.0–4.5 vol%.

Residual muscle relaxation was reversed at the end of anaesthesia by a mixture of methyl-atropine bromide (0.005 mg/kg) and neostigmine (0.04 mg/kg). The anaesthetic gas was stopped when muscle power was adequate. Arterial blood samples were obtained at various times according to the protocol schematically represented in Figure 1. Five ml of blood for catecholamine determination were collected through an indwelling catheter into chilled 10-ml heparinised polystyrene tubes that contained 12 mg glutathione. This was centrifuged within 20 minutes at 4°C (15 minutes, 3000 x g). Plasma was stored at −70°C. Catecholamines were determined by high-performance liquid chromatography with electrochemical detection, as previously described.[9] A further 5 ml of blood for cortisol, prolactin and growth hormone determinations were collected in heparinised tubes. Plasma was separated and stored at −20°C after centrifugation. Cortisol, prolactin and growth hormone were measured with commercial radioimmunoassay kits, plasma sodium and potassium by ion-selective potentiometry (NOVA 1 Biomedical, Waltham, USA). Measurements of blood gases were performed on an ABL300 (Radiometer, Copenhagen, Denmark).

Table 1. Patient data.

	N_2O group	Xe group	Statistical difference
Males/females	10/6	10/6	NS
Age, years, mean (SD)	33 (11)	38 (12)	NS
Weight, kg, mean (SD)	73 (11)	70 (14)	NS
Fentanyl per patient, mg, mean (SD)	0.24 (0.15)	0.10 (0.14)	$p < 0.01$
Average duration of procedure (minutes)	64	63	NS

NS, not significant.

Arterial pressure was monitored directly through a cannula in the radial artery and heart rate derived from the ECG. Muscle relaxation was ensured throughout the procedure. Patients were interviewed the day after to detect awareness during the procedures and to evaluate overall patient acceptability.

Statistics

Student's unpaired *t*-test, as well as the two-way ANOVA, were used for comparison between groups. Comparison within groups was performed with Student's paired *t*-test. p-values of less than 0.05 were considered significant.

Results

Opioids

Incremental fentanyl was needed peroperatively in all patients in the N_2O group and on average more than twice per patient (Table 1). Fentanyl was only needed in eight out of 16 patients, once per patient on average, during Xe anaesthesia. There was no apparent difference in the quality of muscle relaxation or in the need for additional relaxation between the two groups. Awareness, as judged peroperatively and by patient interview a day later,

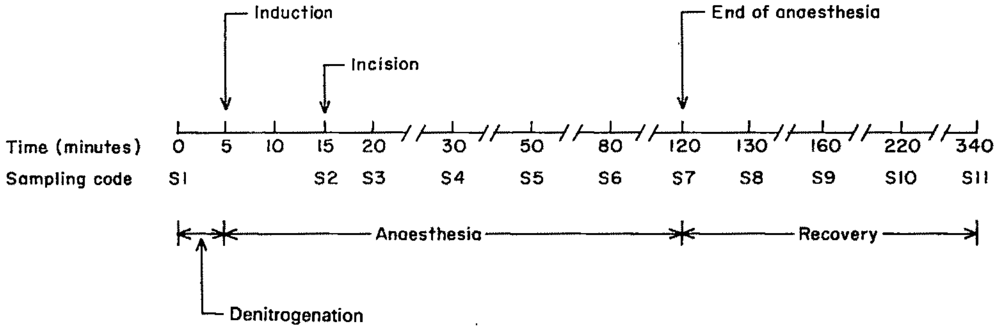

Fig. 1. Protocol for blood sampling.

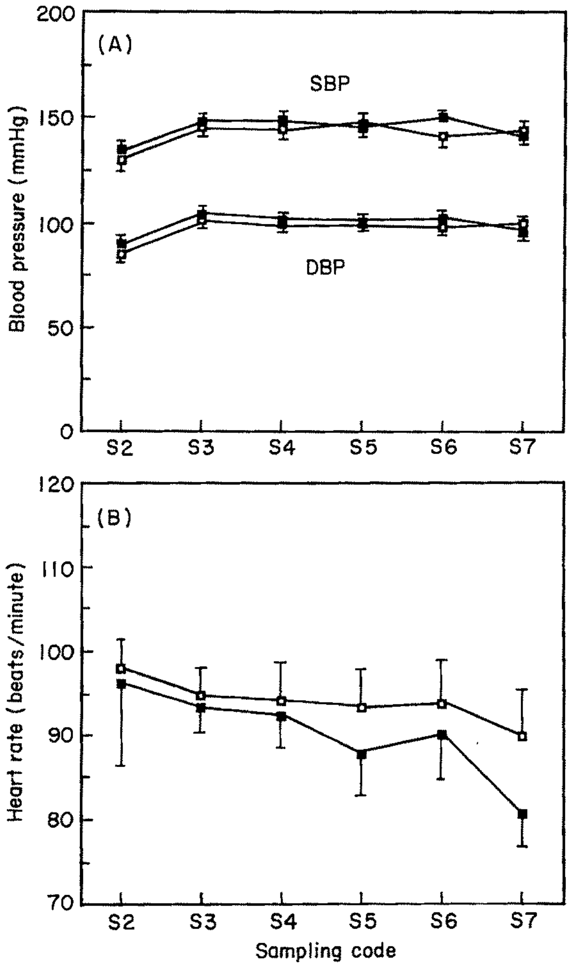

Fig. 2. Mean blood pressures (A) and heart rates (B) (SEM) of the N_2O (open squares) and Xe (closed squares) groups at various sampling times. See Figure 1 for sampling codes. SBP, systolic blood pressure; DBP, diastolic blood pressure.

occurred in none of the participating patients. The quality and duration of recovery from both N_2O and Xe were clinically identical, and it was not possible to say which of the two gases were used.

Haemodynamics

Both systolic and diastolic blood pressures increased slightly but significantly after the first incision, but remained unchanged during the whole course of the operation thereafter (Fig. 2A). Heart rate showed a tendency to decrease slowly during the operation (Fig. 2B), but this tendency did not reach statistical significance. There were no significant differences between the two groups in blood pressure, heart rate, or changes thereof at any time during the observation period.

Catecholamines

Noradrenaline levels in both the N_2O and the Xe groups (Fig. 3A) decreased after induction and thereafter slowly increased during the operation, but did not become statistically different from control, except at S7 in the Xe group. Noradrenaline levels were higher than control values (S8, S9 and S10) after the end of anaesthesia but returned to control values 2 hours later (S11) in the Xe but not the N_2O group. Noradrenaline levels in the Xe group were significantly higher than in the N_2O group ($p < 0.005$); compared to control there were no significant differences between the groups in noradrenaline levels. Adrenaline levels in both groups (Fig. 3B) were decreased after induction and incision (S2 and S3). Adrenaline remained below control values in the Xe group during the operation at S4, S5 and S6, and returned to control values at the end of the operation at S7. On the other hand, adrenaline levels increased continuously during the operation in the N_2O group, although, due to large individual differences, this became only statistically significant at S7. Adrenaline levels were much higher than control values after operation and decreased again with time. In the Xe, but not the N_2O group, adrenaline levels returned to control values at S11. Adrenaline levels in the N_2O group were significantly higher than in the Xe group at S4, S5, S6 and S7, but not

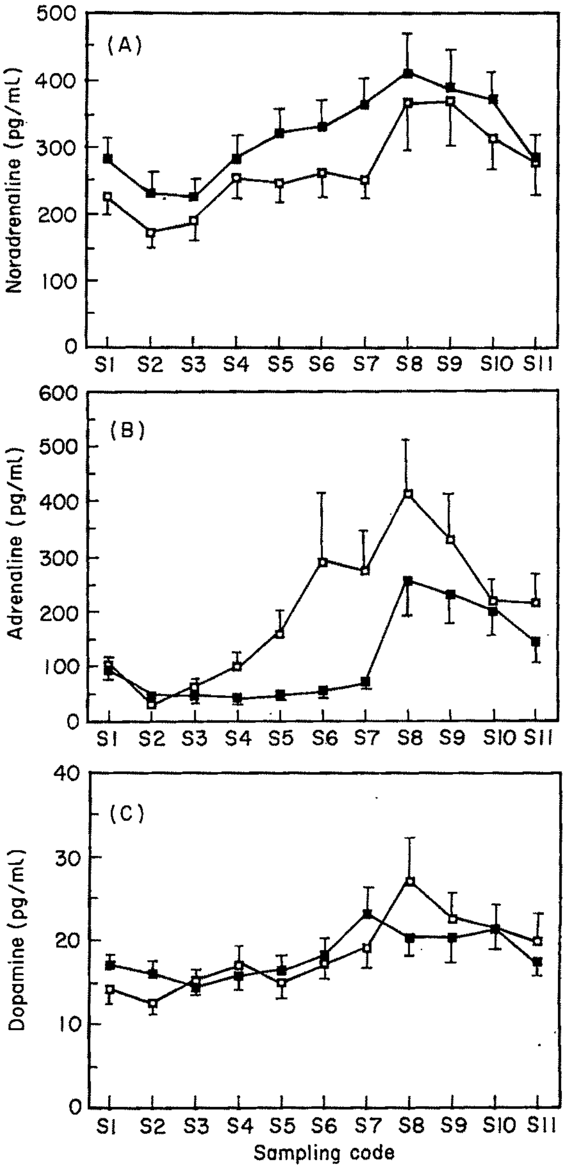

Fig. 3. Mean plasma concentrations of noradrenaline (A), adrenaline (B) and dopamine (C) (SEM) of the N_2O (open squares) and Xe (closed squares) groups at various sampling times. See Figure 1 for sampling codes.

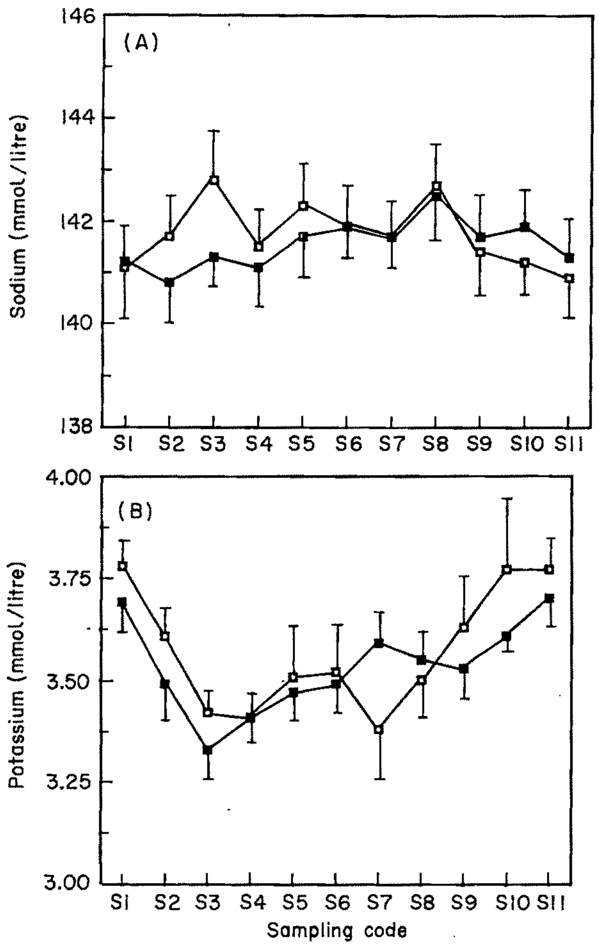

Fig. 4. Mean plasma concentrations of sodium (A) and potassium (B) (SEM) of the N_2O (open squares) and Xe (closed squares) groups at various sampling times. See Figure 1 for sampling codes.

postoperatively. The adrenaline levels between the groups and in comparison with control values within the groups were significantly different ($p < 0.0001$ and $p < 0.025$ respectively).

Dopamine levels in the two groups were at no time different from one another, although postoperatively they were higher than control in the N_2O group (Fig. 3C). Postoperative dopamine responses compared with control values (S1) were different between the two groups; they were greater after N_2O than after Xe.

Electrolytes

No differences were seen in plasma sodium during the whole procedure or between the two groups (Fig. 4A). Plasma potassium (Fig. 4B) decreased after induction and incision (S2 and S3) but thereafter did not decrease any further. Potassium in both groups returned to control values at S10 and S11.

Hormones

Cortisol did not change during anaesthesia and operation in the Xe group (Fig. 5A), but in the N_2O group it was higher than control values at S5, S6 and S7. Cortisol levels after operation were higher than control values in both groups, and decreased thereafter to baseline within 2 hours (S11). Growth hormone in the N_2O group was at no point different from control (Fig. 5B), but in the Xe group it was lower than control at S4-S8. Growth hormone at S6 was higher in the N_2O than in the Xe group. Overall, however, growth hormone did not differ between the two groups. Prolactin levels were similar in both groups (Fig. 5C), and increased after the start of anaesthesia and operation; they decreased again in the postoperative phase. Prolactin levels were still elevated at S11, 2 hours after the operation.

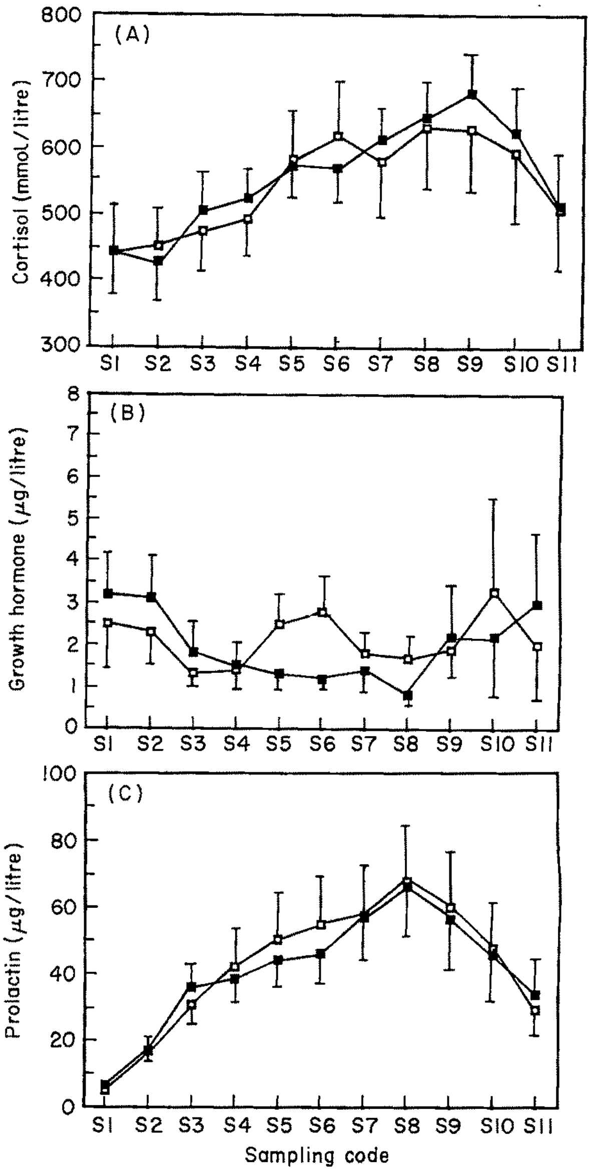

Fig. 5. Mean plasma concentrations of cortisol (A), growth hormone (B) and prolactin (C) (SEM) of the N_2O (open squares) and Xe (closed squares) groups at various sampling times. See Figure 1 for sampling codes.

Discussion

The need for more frequent increments of fentanyl in the N_2O group indicates differences in the antinociceptive effects of N_2O and Xe. The fact that patients were well-matched overall and that duration and type of surgery were comparable, indicates the efficient antinociceptive effects of one MAC Xe. Theoretically, it may perhaps be assumed that one MAC of N_2O would have diminished further the need for incremental opioids. However, the difference of 0.3 MAC for N_2O is too small to account for more than double the need for opioid per patient or per hour of anaesthesia, as compared to the Xe group. In this study, recovery in the two groups was indistinguishable. Theoretically, induction of anaesthesia with Xe would be faster than with N_2O, but this could not be determined in this study. Recovery from either gas is rapid and subject to many uncontrollable factors after operation; this obscures subtle differences between them. Patients were very satisfied with anaesthesia, irrespective of the gas used.

Blood pressure and heart rate were adequately controlled during surgery in both groups of patients, and no difference was seen between the two gases. Present data on N_2O anaesthesia are generally in agreement with previous reports, even though exact conditions of anaesthesia differ widely with respect to the use of fluorinated hydrocarbons, neuroleptic agents and premedication regimen. The increase in plasma adrenaline during surgery agrees with many reports;[10–16] some of these also report the highest levels to be attained postoperatively.[11,12,16] The same goes for noradrenaline, although here the increase in plasma levels during surgery only occasionally,[11–14] but not always[10,15,16] reached statistical significance. Some workers also found the highest levels of noradrenaline in the postoperative phase.[11,13,14] Dopamine was reported previously not to change during the whole surgical procedure.[10,13,16] In contrast, we found a small but significant increase in the postoperative phase.

The increase in cortisol and prolactin during surgery, and the attainment of the highest levels of cortisol postoperatively are in agreement with previous reports.[10,12,15–20] Growth hormone did not change in our study, contrary to the finding of Sowers *et al.*[17] but in agreement with Hempenstall *et al.*[15] The most pronounced difference was the absence of an increase in plasma adrenaline in the patients who received Xe. Noradrenaline increased in a similar way to the N_2O group, and this could indicate that Xe can prevent the activation of the adrenal medullary system, but not the central sympathetic neurons during surgical stress. The finding of unchanged cortisol in the Xe group but increased cortisol in the N_2O group during surgery, as well as the lower growth hormone levels under Xe anaesthesia, also point to a central attenuation of the neurohormonal response to surgical stress by Xe.

The differences between the Xe and N_2O groups could theoretically also have been caused by more fentanyl administered to those who received N_2O. Fentanyl would be expected to have an inhibitory effect, if any, on hormonal responses to surgical stress.[11–13,21,22] Thus, the lack of an increase in adrenaline and cortisol during surgery in the Xe group must be wholly attributed to an effect of Xe, and this effect would, if anything, have been even greater if the same amounts of fentanyl had also been used in this group. This study supports the suggestion by Halter *et al.*[11] that the sympathetic nervous system-activating pathway to the adrenals is distinct from the pathway to the peripheral neurons.

Postoperatively, adrenaline and cortisol levels in the Xe group increased to levels similar to the N_2O group; this indicated that the postsurgery period may be more stressful, with more cardiovascular instability than during the period of surgery itself. The effects of both types of anaesthesia on plasma electrolytes (potassium and sodium) were not different.

It transpires from this study that both Xe and N_2O provide excellent anaesthesia, with Xe being slightly superior. Of greater importance are the findings that indicated more stable cardiovascular conditions during Xe anaesthesia. Biochemical side effects of N_2O can now be prevented or treated,[1] but such effects are not known to occur with Xe. The agent probably deserves a more prominent place in anaesthetic practice than it has so far occupied.

Acknowledgments

We thank Dr S. Armbruster and Dr W. Schairer for their help during this study. Xenon was kindly provided by Siemens.

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Detecting awareness during general anaesthetic Caesarean section

An evaluation of two methods

D. G. BOGOD, J. K. ORTON, H. M. YAU AND T. E. OH

Summary

Seventy-four patients received general anaesthesia for Caesarean section. Seven percent of the elective group and 28% of the emergency patients reported dreaming or recall of voices during the procedure ($p < 0.05$) at postoperative interview. One patient from each group reported feeling pain or suffocation. All patients were monitored for awareness using the isolated forearm technique and lower oesophageal contractility. Provoked lower oesophageal contractility was the most effective of the different indices. A value greater than 35 mmHg on at least one occasion had a false negative rate of 33%, a false positive rate of 28% and a predictive value of 25%. A value greater than 13 mmHg picked up all patients who dreamed, with a false positive rate of 68%. Both of the 'aware' patients had provoked lower oesophageal contractility response of greater than 70 mmHg, an attribute shared by only 8% of the rest. The isolated forearm was particularly ineffective.

Key words

Complications; awareness.
Equipment; oesophageal contractility monitor.

Awareness during general anaesthesia is a problem which has become increasingly recognised since the routine use of muscle relaxants. The spectrum of awareness ranges from dreaming, through recall of specific events, to the rare but very serious complication of full consciousness with total paralysis.[1] It has long been recognised that this is a particular problem during Caesarean section, where no sedative premedication, low inspired concentrations of nitrous oxide and volatile agent, and witholding of opioids until after delivery, all contribute to the risk of awareness.

Tunstall[2] described his technique for monitoring for awareness during Caesarean section in 1977. The method relies on isolation of the forearm from the effects of neuromuscular blockade by occlusion of the circulation with a pneumatic tourniquet inflated before injection of muscle relaxant. Movement of the hand in response to a taped message played to the patient is then monitored.

The measurement of lower oesophageal contractility (LOC) as a monitor of depth of anaesthesia was first described in 1984.[3] Later work[4] showed that, in patients who have surgery, decreasing inspired halothane concentration was associated with an increase in LOC, which correlated with an increasing 'awareness score' based on clinical signs. The two prime derivatives of LOC measurement are spontaneous LOC (SLOC), a nonpropulsive contraction that originates in the vagal motor nuclei and reticular activating system, and provoked LOC (PLOC), obtained by the momentary inflation of a balloon in the lower oesophagus.

This study was designed to discover the incidence of awareness and dreaming during Caesarean section performed under nonstandardised general anaesthesia, and determine the value of the isolated arm and LOC techniques in anticipating these problems.

Method

The study protocol was submitted to, and approved by, the Ethics Committee of the Prince of Wales Hospital, Shatin, Hong Kong. Seventy-four consecutive patients who had Caesarean section under general anaesthesia during office hours gave informed consent to participation in the study.

Anaesthesia was administered by registrars, under the supervision of one of the authors. The protocol, as a deliberate policy, did not call for a rigid anaesthetic sequence to be used, since one of the intentions was to find the incidence of awareness under normal conditions. In practice, however, the technique used was *uniform, with*

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only minor variations. Sodium citrate 30 ml was administered before induction; elective cases also received two doses of ranitidine 150 mg beforehand. The patient was placed on the operating table with lateral tilt. A sleep dose of thiopentone was followed by suxamethonium 100 mg through an indwelling cannula after 3 minutes of preoxygenation and application of cricoid pressure. The patient's lungs were ventilated, after intubation, to an end-tidal $P\text{CO}_2$ of 4.0 kPa using a Manley ventilator that delivered 50% nitrous oxide, 50% oxygen and 1% enflurane. Atracurium or vecuronium were used to maintain muscle relaxation. Ten units of syntocinon were administered after delivery, followed by fentanyl 200 µg or morphine 10–15 mg. The $F\text{IO}_2$ was reduced to 0.3 and the enflurane was stopped when deemed appropriate by the clinical and vital signs. Reversal of residual neuromuscular blockade was achieved using atropine 0.6 mg and neostigmine 2.5 mg.

The researcher who supervised the anaesthetic placed a sphygmomanometer cuff around the forearm of the patient and inflated it to 200 mmHg immediately before induction; this isolated the hand from the effects of the muscle relaxant. The headphones of a cassette player were placed over the patient's ears, and a message played in Cantonese asking the patient to open and close her hand if she could hear the message and would rather be more deeply asleep. This was repeated every 2 minutes throughout the period of the trial. The cuff was deflated after 20 minutes to prevent ischaemic paralysis, but was re-inflated before any further boluses of neuromuscular blocking drugs were administered. Arm activity was scored for each period of one minute as no movement (0), nonspecific movement (1), or firm clenching/flexing movement (2).

An oesophageal probe was passed blindly, immediately after tracheal intubation and confirmation of correct tube placement, and its position confirmed by hearing breath sounds on auscultation of the channel to the provocation balloon. Recording of lower oesophageal contractility was made by connecting the sensing balloon channel via an external pressure transducer to a lower oesophageal contractility recorder (Lectron 301, Antec Systems) and to a chart recorder for hard copy. The provocation balloon was inflated for a period of 5 seconds every 2 minutes automatically by the Lectron 301. An oesophageal contraction was considered to have occurred when a pressure transient of greater than 10 mmHg was recorded, in order to distinguish it from the normal pressure fluctuations that occurred with ventilation. The contraction was recorded as a provoked LOC (PLOC), if it followed within 10 seconds of a provocation, otherwise it was considered to be a spontaneous LOC (SLOC).

At no time during the case did the anaesthetist have access to the results of the isolated arm or LOC monitors; any alteration in concentration of volatile agent was prompted by clinical and vital signs only. The study continued for 30 minutes or until surgery ended, whichever was sooner. Each patient was visited by a Cantonese-speaking anaesthetist at approximately 24 hours after surgery, who asked them a series of questions about dreaming, awareness and pain during the period of anaesthesia.

Statistical analysis. The Chi-squared test was used to analyse incidence of awareness and the isolated forearm results. Student's *t*-test was used to analyse oesophageal contractility.

Table 1. Incidence of awareness in elective and emergency patients.

Type of surgery	Deep	Light	Aware
Elective	52 (93%)	4 (7%)	1
Emergency	13 (72%)	5 (28%)	1
Total	65 (88%)	9 (12%)	2

Results

Awareness (Table 1)

Seventy-four patients were included in the trial; 56 had elective Caesarean sections for a variety of indications. Four of this group (7%) had dreams or heard voices during the period of anaesthesia, one of whom felt discomfort. She was not unduly upset, and reported the same sensation during a previous Caesarean section. Five (28%) of the 18 patients who had emergency procedures reported recollection of dreams or voices, one of whom recalled an unpleasant suffocating sensation. Enflurane 1% had been delivered in 100% oxygen in error in one of these patients. Two patients who had reported painful awareness during previous Caesarean sections did not have any repetition of the problem on this occasion. The difference in incidence of dreaming between the elective and emergency patients was statistically significant ($0.02 < p < 0.05$).

The nine patients who reported dreaming are hereafter grouped together as the 'light' group, and the 65 other patients as the 'deep' group, for the purpose of clarity. Two of the patients in the 'light' group have been subclassified as 'aware'.

Isolated arm

Figure 1 shows the number of patients in the two groups who exhibited arm movements, grouped in 5-minute intervals from induction. The incidence of movement, especially type 2 (firm, clenching), is higher in the light patients in the first 10 minutes, although this is not statistically significant. However, the use of type 2 movement as an indicator of potential awareness is severely limited by the lack of specificity and sensitivity. Thus, 28% of the deep patients exhibited type 2 movement in the first 5 minutes (false positive), whereas 56% of the light patients failed to (false negative). Worse, because of the relatively few patients who were light, 18 of the 22 patients who showed this type of movement in the first 5 minutes were in the deep group; they gave a predictive value (proportion of true positives amongst apparent positives) of only 18%. Neither of the aware patients had any type 2 movement. The only problem associated with the use of the isolated arm technique was the appearance of petechial haemorrhages on the forearm distal to the cuff in 13 patients (18%), all of which resolved within 48 hours.

Spontaneous lower oesophageal contractility

No problems were encountered with the passage or positioning of the oesophageal probe.

Figure 2 shows the mean number of SLOCs per minute for each 5-minute period for the two groups. The light patients consistently recorded a higher mean SLOC rate, but the wide variation between patients results in large

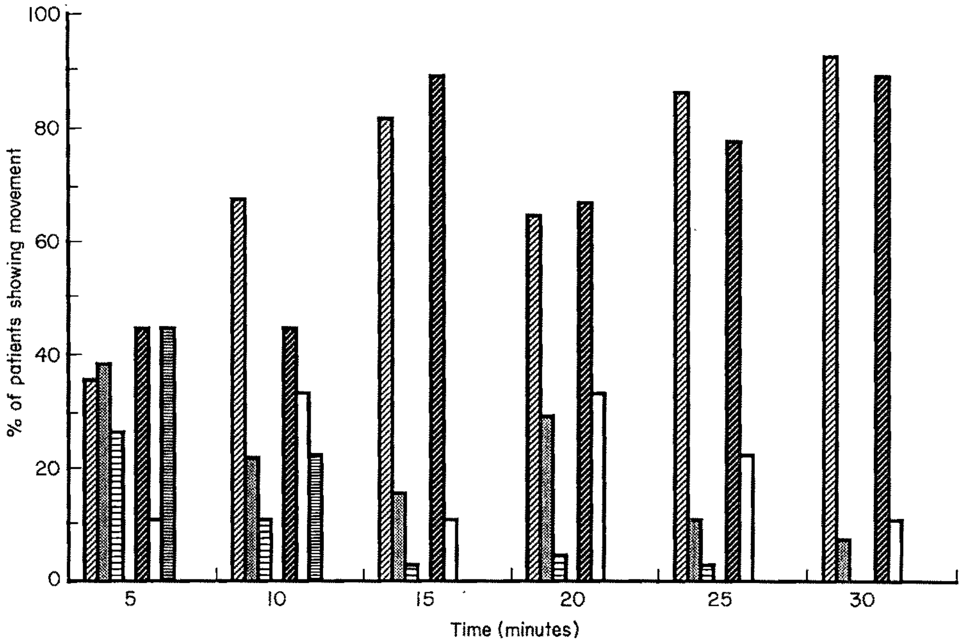

Fig. 1. Percentage of deep and light patients showing isolated-arm activity at 5-minute intervals after induction. ▨, deep, no movement; ▩, deep, firm, clenching movement; ⊟, light, nonspecific movement; ▨, deep, nonspecific movement; □, light, no movement; ▤, light, firm, clenching movement.

standard deviations; this makes the difference statistically insignificant. A SLOC rate of greater than 10 per minute at any time in the first 5 minutes was the best discriminator between the light and deep patients, with a 22% false positive and 44% false negative rate. The predictive value of a positive result is 18%. A SLOC rate of greater than four per minute in the first 5 minutes would have to be used as the cut-off point to pick up all the patients in the light group (0% false negative rate). This would give a false positive rate of 74%, and a predictive value of 16%. SLOC is also unhelpful in distinguishing the patients classified as aware.

Provoked lower oesophageal contractility

Figure 3 shows the data derived from the mean PLOC values for the two groups for each 2-minute interval. The values in the light group, as with SLOC, are consistently higher, but this only reaches statistical significance at the 30-minute recording. PLOC does, however, provide the simplest and most effective way of distinguishing the groups; a PLOC greater than 35 mmHg at any time has a false positive rate of 28%, and a false negative rate of 33%, with a predictive value of 25%. To achieve a false negative rate of 0%, a PLOC greater than 13 mmHg would have to

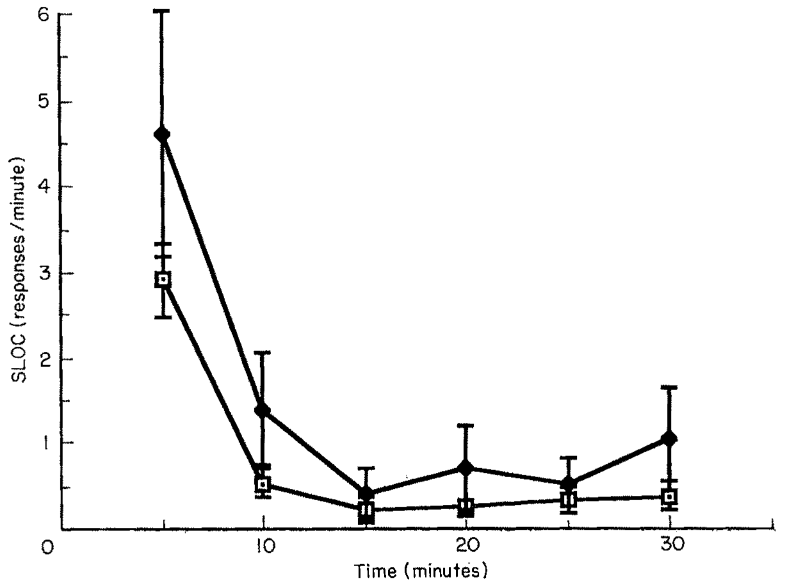

Fig. 2. Mean (SEM) spontaneous lower oesophageal contraction (SLOC) rate per minute in deep and light patients at 5-minute intervals after induction. —⊡—, deep; —●—, light.

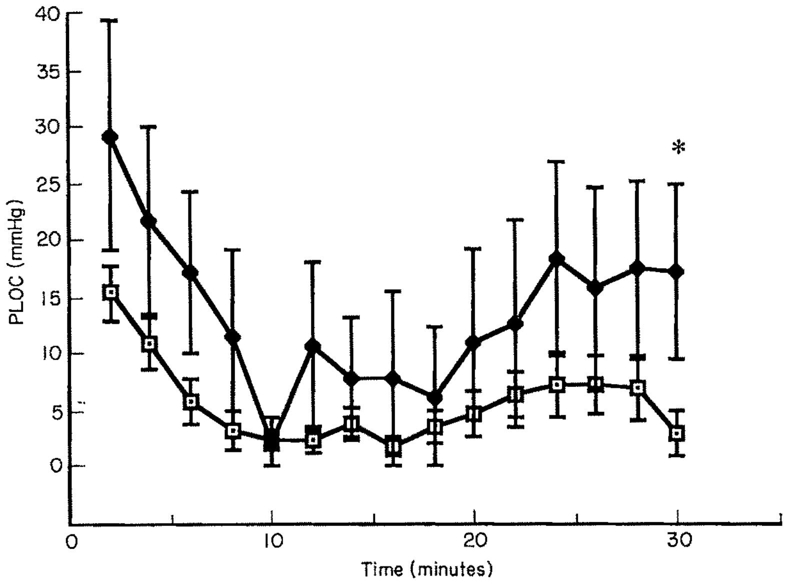

Fig. 3. Mean (SEM) height of provoked lower oesophageal contraction (PLOC) in deep and light patients at 2-minute intervals after induction. —⊡—, deep, —●—, light; *$p < 0.05$.

be taken as the 'cut-off' point; this would give a false positive rate of 68% and a predictive value of 17%. PLOC is particularly good at picking up the two aware patients, both of whom had PLOCs greater than 70 mmHg on at least one occasion. This test yields a false positive rate of only 8% and a predictive value of 25%.

Oesophageal contractility index

The oesophageal contractility index (OCI) is a calculated value derived from the SLOC rate and height of PLOC at any one time.[5] The formula is:

$$\mathrm{OCI} = \mathrm{PLOC} + (70 \times \mathrm{SLOC})$$

OCI was calculated in this study for each 2-minute interval by combining the mean SLOC rate for that period with the PLOC value that occurred at the end of it (Fig. 4). The difference between the light and deep groups reaches statistical significance on four occasions. Individual OCI values are too variable to be useful predictors, although the mean OCI over the first 10 minutes of the procedure proves to be as useful as the PLOC indicators outlined above. Thus, a mean OCI (first 10 minutes) of greater than 150 has a false positive rate of 29%, a false negative rate of 22%, and a predictive value of 27%. All the light group are picked up if the cut-off point is reduced to 70, but at the expense of a false positive rate of 72%, and a predictive value of 17%. A mean OCI (first 10 minutes) of greater than 270 picks up both the aware patients, with a false positive rate of 8% and a predictive value of 25%.

The sensitivity, specificity and predictive value of the various tests are summarised in Table 2.

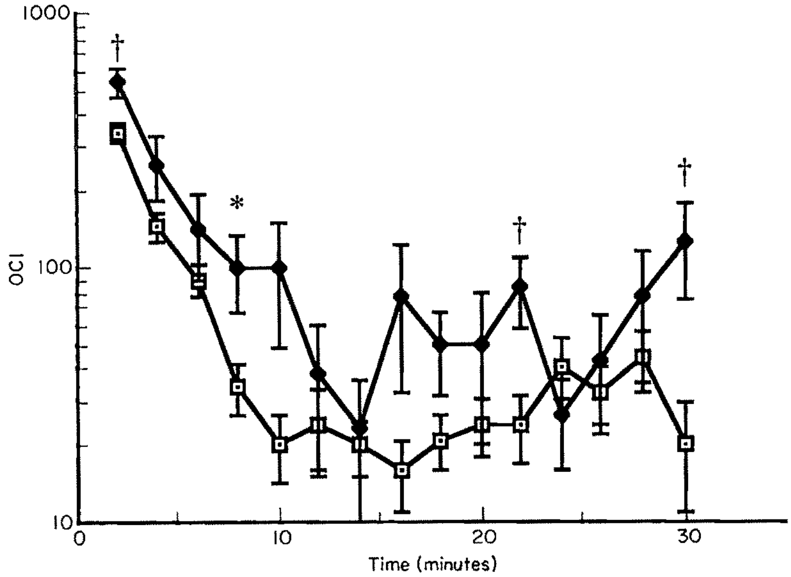

Fig. 4. Mean (SEM) oesophageal contractility index (OCI) in deep and light patients at 2-minute intervals after induction. —⊡—, deep; —●—, light; *$p < 0.05$; †$p < 0.025$.

Table 2. Specificity, sensitivity and predictive value of different indices of awareness.

	Deep compared with light		
Isolated arm	False positive (%)	False negative (%)	Predictive value (%)
Type 2 movement in first 5 minutes	28	56	18
SLOC (contractions/minute)			
>10*	22	44	18
>4*	74	0	16
PLOC (mmHg)			
>35	28	33	25
>13	68	0	17
OCI			
>150†	29	22	27
>70†	72	0	17
	Aware compared with rest		
PLOC (mmHg)			
>70	8	0	25
OCI			
>270†	8	0	25

*At any time in first 5 minutes.
†Mean over first 10 minutes.

Discussion

The provision of anaesthesia for Caesarean section by the use of unsupplemented 50% nitrous oxide in oxygen until delivery of the fetus was common in the 1960s, and this was associated with an incidence of 'unpleasant awareness' ranging from 12–26%,[6,7] and a likelihood of 2% of awake patients.[8–10] Moir[11] described the use of 0.5% halothane as a supplement to 50% nitrous oxide in 1970 and, with slight variations, this has become a widely accepted technique. Several reports have denied any intra-operative recall with this technique, although dreaming has not been investigated.[6,11–13]

The present study shows that a large proportion of patients had dreams, mostly not unpleasant, while anaesthetised for Caesarean section. The relationship between dreams and light anaesthesia is not fully established, and some of these patients, despite the best efforts of the interviewers, may have been describing their experiences during the postoperative recovery period. It is reasonable to assume, however, that the dreams experienced by many of these patients, which consisted of hearing several voices talking, reflected a degree of awareness during the procedure.[14,15] The higher incidence of dreaming in the emergency group (28% compared with 7%) has not been previously described, and may be related to the greater degree of anxiety that would be anticipated in these patients. Two patients reported awareness that could be classified as 'unpleasant recall', not previously described with this type of anaesthetic technique. It is particularly interesting that one of these patients reported a similar experience during previous surgery; there was no history of chronic alcohol or drug abuse which might render her resistant to the effects of anaesthetic agents.

The isolated forearm technique was an unhelpful indicator of the patients in the light or aware groups; deliberate movement in response to command was unrelated to depth of anaesthesia. This agrees with the findings of Breckenridge and Aitkenhead[16] who showed poor correlation between response to command of the isolated arm and clinical signs of light anaesthesia. Indeed, in Tunstall's original study,[2] none of the patients who showed purposeful movement of the isolated arm reported any recall of events. The ineffectiveness of this method combined with the problem of petechial haemorrhages in 18% of patients suggests that its routine use in obstetric anaesthesia should be carefully reviewed.

The relative importance of false negative and false positive results should be borne in mind when considering the value of any test for detecting awareness. In this case it would be far less acceptable for an aware patient to go undetected (false negative) than for an anaesthetic agent to be unnecessarily increased (false positive). The lowest false positive rate associated with no false negatives is found when a PLOC greater than 13 mmHg is used as a cut-off (68% of patients would have their anaesthetic unnecessarily deepened). This, then, describes a screening test which has high sensitivity but very low specificity. The other indices of LOC fare even worse than this with regard to specificity; OCI (oesophageal contractility index) comes a close second. PLOC has the added advantages over OCI in that it does not need to be calculated or averaged out over the first 10 minutes of the procedure, by which time any action may be too late to prevent recall.

LOC is more effective, however, when used to predict the two patients who reported unpleasant recall. A single PLOC of greater than 70 mmHg, or a mean OCI over the first 10 minutes of greater than 270, were both 100% effective at identifying these patients with only an 8% false positive rate. The low incidence of this complication means that the predictive value of these tests is still low (75% of the time, action would still be taken unnecessarily), but this is a small price to pay for the ability to predict serious awareness. The small number of patients in this group means that a much larger study would be required to confirm these findings.

The spectre of awareness is not new, but is increasingly the subject of public debate and litigation. The lack of a suitable monitor for depth of anaesthesia is a matter which should cause serious concern to all anaesthetists. This study has demonstrated that the isolated forearm technique, although simple and cheap to use, is of little or no use for this purpose. The more invasive, complicated and expensive lower oesophageal contractility monitor is able to detect patients who are inadequately anaesthetised, but the wide interpatient variability means that a large number of adequately anaesthetised patients are 'picked up in the net'. Provoked lower oesophageal contractility (PLOC) seems to be the most promising of the various LOC indices. This study also suggests that patients who require emergency Caesarean section may be more prone to awareness than those who have elective procedures.

Acknowledgments

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Epidural fentanyl and 0.5% bupivacaine for elective Caesarean section

M. J. KING, M. I. BOWDEN AND G. M. COOPER

Summary

Either 100 μg fentanyl or 2 ml saline was added to 0.5% bupivacaine administered epidurally for elective Caesarean section in 30 patients, in a double-blind randomised study. Bupivacaine 0.5% was administered until a complete sensory block was established extending to the 4th thoracic dermatome. One of the patients who received epidural fentanyl required intravenous alfentanil and Entonox and another, Entonox only briefly during surgery, compared with seven in the control group who required intravenous alfentanil and Entonox and one who required Entonox only. Postoperative analgesia was of longer duration in those who received epidural fentanyl ($p < 0.01$). There were no deleterious effects on neonatal or maternal outcome.

Key words

Anaesthetic techniques, regional; epidural.
Analgesics, narcotic; fentanyl.

Epidural anaesthesia has clear advantages over general anaesthesia for the management of elective Caesarean section. The anaesthetist can avoid manipulation of the maternal airway, the neonate avoids the depressant effects of general anaesthetics and the mother can participate in the birth of her child, encouraging early bonding. However, even with an apparently good block, the mother may experience some discomfort or even pain during surgical manipulations which may mar the experience for her or worse, necessitate the rapid conversion to general anaesthesia with its inherent risks. Two per cent of patients require conversion of epidural anaesthesia to general anaesthesia despite effective blockade from S_5–T_4.[1]

Epidural opioids have been widely investigated for labour and postoperative pain in obstetrics, but are not used routinely for Caesarean section. Morphine was administered, in a Scandinavian study,[2] after the delivery of the baby at Caesarean section, and it was noted that, when this was given in combination with bupivacaine, the discomfort from stretching and dragging of the tissues was less intense. Epidural fentanyl,[3] in a dose of at least 50 μg again administered after the delivery of the baby, was effective in relief of intra-operative discomfort, which occurred despite blockade from S_5 to T_4.

Some discomfort can occur at the time of delivery and any drug administered subsequently takes a finite time to be effective. The onset of action of epidural fentanyl is faster than most opioids, but there is still a latency of 10–15 minutes,[4] favouring early administration.

The use of opioid administration before delivery at Caesarean section is inhibited by the fear of neonatal ventilatory depression. This fear has been allayed to an extent by results of studies[5,6] that show low maternal and placental cord blood concentrations of fentanyl after maternal epidural administration.

Gaffud *et al.*[7] have given epidural fentanyl before delivery at Caesarean section and found effective analgesia in their assessment of pain at 15-minute intervals. Further study appeared to be indicated so we investigated the efficacy, at specific events during surgery, of the administration of 100 μg fentanyl epidurally before the start of Caesarean section in a randomised double-blind manner.

Methods

We studied 30 healthy patients scheduled to undergo elective Caesarean section at a gestation of 36 weeks or greater. Routine antacid prophylaxis (30 ml mist. mag.

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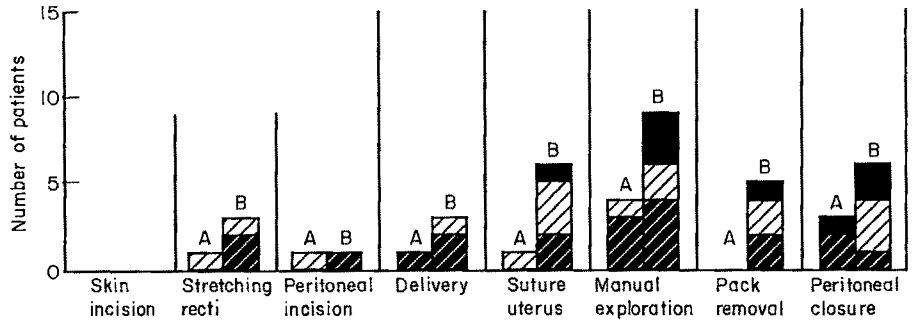

Fig. 1. Number of patients in group A (fentanyl) and group B (saline) who experienced mild, moderate or severe pain at eight operative events. ▩, mild pain (no treatment); ▨, moderate pain (entonox); ■, severe pain (alfentanil).

trisilicate) was the sole premedication. All patients gave consent and the study was approved by the Hospital Ethics Committee.

An epidural catheter was inserted via either the $L_{2/3}$ or $L_{3/4}$ interspace, with the exception of one patient who had a marked lumbar lordosis that required placement of the catheter in the $L_{1/2}$ interspace. Bupivacaine 3 ml 0.5% was injected through a Millipore filter as an epidural test dose. A further 7 ml 0.5% bupivacaine was subsequently injected in divided doses over 5 minutes. The maternal circulation was preloaded with 1 litre of compound sodium lactate solution, and maternal arterial blood pressure (Dinamap Critikon) and fetal heart pattern were continuously monitored. Sitting, lateral or wedged to the right positions were maintained throughout.

The mothers were randomly allocated to receive the next epidural top-up in divided doses over 10 minutes of, either 8 ml 0.5% bupivacaine plus 100 μg fentanyl (group A) or 8 ml 0.5% bupivacaine plus 2 ml 0.9% saline (group B). These solutions were made up by an independent anaesthetist and neither the anaesthetist involved in the study, nor the patient was aware of whether fentanyl or saline was administered. The level of anaesthesia attained was tested with ethyl chloride spray at 5-minute intervals. Additional increments (up to 5 ml) of 0.5% bupivacaine were administered until a bilateral sensory block to T_4 was attained. The total volume injected epidurally and the time taken to attain block to T_4 were recorded.

Intra-operative pain was assessed by the author (M.K. or M.B.) conducting the anaesthetic. The mothers were asked to rank any pain as absent, mild, moderate or severe at eight stimulating events; skin incision, stretching of the recti muscles, peritoneal incision, delivery, suturing the uterus, manual exploration, removal of the pack and peritoneal closure. Mild pain was regarded as discomfort that did not require treatment. Patients were offered Entonox to breathe, if they appeared in more discomfort, and if satisfactory analgesia was provided the pain was confirmed as moderate. Any pain that required intravenous alfentanil in addition to Entonox was classified as severe.

Mothers were continually observed for side effects including nausea, vomiting, pruritus, hypotension, sedation and clinical evidence of ventilatory depression (respiratory rate < 12 breaths per minute). Hypotension was defined as a decrease in systolic pressure of 20% or greater. This was treated with further intravenous fluid or ephedrine to maintain normotension throughout the procedure. All patients received syntocinon 10 IU intravenously after delivery.

Neonatal outcome was assessed by Apgar scores at 1 and 5 minutes and umbilical arterial and venous blood gas analysis.

All mothers were observed on a recovery unit after operation and subsequently returned to the ward. The next day all were visited by one of the authors and the time of administration of postoperative analgesia recorded. Patients were asked when the sensory and motor blocks had worn off and if they were satisfied with their operation and anaesthesia, and how they perceived the memory of intra-operative discomfort.

Patient data and the duration of analgesia were analysed by unpaired *t*-test and the requirement for additional intra-operative analgesia and the incidence of complications were compared by Chi-squared test with Yates' correction for small numbers.

Results

Maternal effects

There were no significant differences in maternal age or weight among the 15 mothers in each group, nor in the volume of epidural bupivacaine 0.5% required to produce blockade to T_4, nor in the speed of onset of block (Table 1).

Figure 1 shows the number of patients at each surgical event who experienced mild, moderate or severe pain. No patient experienced discomfort at skin incision and those

Table 1. Maternal data and volume of epidural 0.5% bupivacaine, time to achieve block to T_4 from administration of epidural fentanyl or saline and duration of sensory and motor blocks, mean (SD).

	Group A (fentanyl) $n=15$	Group B (saline) $n=15$
Age, years	30.5 (6.6)	31.9 (4.8)
Weight, kg	69.5 (11.7)	75.2 (11.3)
Volume of bupivacaine administered, ml	22.9 (4.9)	21.5 (4.5)
Time to achieve block to T_4, minutes	30.3 (12.9)	31.9 (14.7)
Duration of sensory block, minutes	448 (191)	384 (190)*
Duration of motor block, minutes	446 (194)	356 (182)*

*$p<0.01$.

Table 2. Numbers of patients who recalled discomfort during surgery. In parentheses are the numbers of patients who volunteered and were observed to have discomfort at the time of surgery.

	Group A (fentanyl) $n=15$	Group B (saline) $n=15$
Severe pain (alfentanil)	0 (1)	3 (7)
Moderate pain (Entonox)	2 (1)	2 (0)
Mild pain (no treatment)	3 (4)	3 (2)
No pain	9 (9)	7 (6)

Table 3. Numbers of patients observed to have side effects.

	Group A (fentanyl) $n=15$	Group B (saline) $n=15$
Itching	13	2*
Nausea	10	9
Vomiting	1	1
Hypotension	3	7
Dizziness	1	2
Drowsiness	1	1
Ventilatory depression	0	0

*$p<0.01$.

who received epidural fentanyl exhibited consistently less surgical pain. At some point during surgery, of those who received epidural fentanyl, two patients needed Entonox, of whom one required intravenous alfentanil. In contrast, of those who did not receive epidural fentanyl, eight needed Entonox of whom seven required intravenous alfentanil. Fewer mothers who received epidural fentanyl experienced severe pain ($p < 0.05$).

One mother who received epidural fentanyl and two who did not, only required orally administered analgesics after operation. The mean time to administration of postoperative analgesia in the epidural fentanyl group was 485 minutes (SD 169) and in the saline group 294 minutes (SD 93) ($p < 0.01$).

All mothers who received epidural fentanyl were fully satisfied with their anaesthetic including one who suffered severe pain. Two mothers who did not receive epidural fentanyl believed they were helped by the epidural, but they were not completely satisfied. Table 2 shows the number of mothers at the postoperative visit who perceived their intra-operative pain as severe, moderate, mild or absent compared with the observations during surgery. Only three of the eight mothers who complained of severe pain at the time of surgery volunteered this information the next day.

Intra-operative side effects noted by the observer are listed in Table 3. More of those in group A than in group B were noted to be itching ($p < 0.01$), although this was never severe. There was no difference between the groups in the occurrence of other side effects, none of which was severe or interfered with the conduct of surgery.

Neonatal outcome

There was no difference between the mean weights of the babies born in group A, which was 3.53 kg (SD 0.42) and those in group B which was 3.44 kg (SD 0.47). There were no differences in the base deficits measured on umbilical arterial and venous blood samples (Table 4) nor in the Apgar scores. All Apgar scores were 9 or 10 by 5 minutes after birth and no drugs were required in neonatal resuscitation.

Discussion

There is no doubt that during a study to investigate a subjective phenomenon such as pain, the anaesthetist does not behave in the same way as during routine clinical practice. Only 12% patients in this hospital[8] normally receive supplementary analgesia for Caesarean section once epidural blockade has been satisfactorily established. Both the anaesthetist and the patient in this study were made to focus on the presence or absence of pain during the operation at specific surgical interventions. The study design indicated immediate pharmacological treatment if the pain was described as moderate or severe, whereas the presence of such pain might well have been short-lived, and dealt with by psychoprophylaxis and reassurance in routine clinical practice. Nevertheless, of those who received epidural fentanyl only one of the 15 patients required intravenous alfentanil compared with seven of the 15 who did not receive epidural fentanyl. There was a striking

Table 4. Numbers of neonates with Apgar scores <7, 7, 8, 9 and 10 at 1 and 5 minutes after birth. The mean base deficits on umbilical arterial and venous blood.

		Group A (fentanyl) $n=15$		Group B (saline) $n=15$	
		1 minute	5 minutes	1 minute	5 minutes
Apgar score	10	0	6	0	7
	9	13	9	13	8
	8	0	0	1	0
	7	2	0	1	0
	<7	0	0	0	0
Umbilical arterial base deficit (SD)		4.0 (1.7)		4.0 (2.0)	
Umbilical venous base deficit (SD)		3.4 (1.7)		2.8 (2.1)	

superiority in the quality of the block in those who received epidural fentanyl. Our study compares favourably with that of Gaffud *et al.*[7] in which two out of 10 patients who received epidural fentanyl required supplemental analgesics. Seven out of 10 of their patients who received a placebo needed additional analgesia and a further two required general anaesthesia.

The results of a similarly designed investigation[9] to ours using 2% lignocaine with 1 in 200 000 adrenaline became available to us during the course of our study. The intensity of surgical pain was found to be consistently less in those patients given epidural fentanyl and none of these required intravenous opioid supplementation compared with five of 15 who did not receive epidural fentanyl.

Another finding in our study was the markedly prolonged duration of postoperative analgesia. Those who received epidural fentanyl did not require further analgesia for 8 hours compared with 5 hours after bupivacaine alone. This compares favourably with 4.9 hours analgesia produced by 50 μg fentanyl with 0.5% bupivacaine,[10] 3.4 hours when fentanyl is combined with 2% lignocaine and 1 in 200 000 adrenaline[11] and 3.8 hours when given diluted with saline.[12] The longer duration of analgesia was accompanied by a sensory and motor block of longer duration. Previous studies have commented on the longer duration of analgesia, but not on the duration of local anaesthetic action. The long duration of motor block was not complained about by our patients, but is not always desirable. Cousins and Mather[13] questioned whether subtherapeutic doses of local anaesthetics and opioid drugs may have synergistic effects.

The maternal perception of pain at the postoperative visit is at variance with their indication on the day of surgery. Only three of eight mothers who said their pain was severe at the time of surgery recalled it as so the next day. Presumably this is analogous to the amnesia of labour pains after delivery. Nevertheless, it is distressing to anaesthetists to conduct an anaesthetic in the presence of apparently imperfect analgesia, and the postoperative visit is important in order that both parties should put the problem into perspective.

We found no differences in the neonatal outcome between our two groups. One would not expect epidural fentanyl to have any effect on fetal blood gases, but the presence of fetal acidosis may predispose to trapping of fentanyl in the fetus, to result in higher neonatal plasma concentrations relative to maternal plasma concentrations and increase the risk of neonatal ventilatory failure. Previous studies[5,9] have indicated virtually insignificant fetal blood concentrations of fentanyl after similar doses to ours. In another study,[6] a neonate required intubation after a vaginal delivery where the mother had received 200 μg fentanyl over several hours, but it is not clear whether the fentanyl was a major contributory factor to the need for intubation. A much larger study than this is required to assess neonatal wellbeing fully; however, since both a paediatrician and anaesthetist are present at Caesarean sections we believe that the technique is inherently safe.

We conclude that the administration of 100 μg fentanyl epidurally, before delivery, significantly improves intraoperative comfort and the duration of postoperative analgesia.

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Footnote

Since this study was completed, an obstetric patient has been described in whom administration of 100 μg fentanyl with bupivacaine led to profound respiratory depression 100 minutes later.[14]

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The effect of diltiazem on the cardiovascular response to tracheal intubation

K. MIKAWA, J. IKEGAKI, N. MAEKAWA, R. GOTO, H. KAETSU AND H. OBARA

Summary

The efficacy of diltiazem in the attenuation of the cardiovascular response to laryngoscopy and tracheal intubation was studied in patients who received 0.2 or 0.3 mg/kg diltiazem 60 seconds before the start of laryngoscopy. These data were compared with a control group who received saline. Each group consisted of 10 patients who had elective surgery. Patients who received saline showed a significant increase in mean arterial pressure and rate pressure product associated with tracheal intubation. These increases after tracheal intubation were reduced in diltiazem-treated patients compared with those of the control group ($p < 0.05$). The data suggest that a bolus injection of diltiazem is a simple, practical and effective method to attenuate the hypertensive response to laryngoscopy and tracheal intubation.

Key words

Intubation; tracheal.
Pharamcology; diltiazem.

The haemodynamic response to tracheal intubation,[1] such as hypertension, tachycardia and arrythmias, is of considerable interest to anaesthetists. Increases in mean arterial pressure from 20 to 50 mmHg when compared with awake control values, and 35 to 65 mmHg when compared with pre-intubation values, are reported to occur after placement of a tracheal tube.[2-5] Such cardiovascular disturbances may be dangerous in some patients, particularly those who suffer from myocardial disease. This stress response can be attenuated by a low dose of fentanyl, local anaesthetics, α- or β-adrenergic blocking agents and other drugs with vasodilator properties.[1,6] Recently, it has been reported that the calcium channel antagonists, nifedipine and verapamil are also effective in the control of haemodynamic response associated with laryngoscopy and intubation.[7,8]

The present study was designed to evaluate the efficacy of another calcium blocking agent, diltiazem, in the attenuation of this response.

Methods

The study was approved by the Human Investigation Committee of Kobe University School of Medicine and informed consent was obtained from all patients after a full explanation. The investigation was carried out in two parts. Initially 10 patients (ASA grade 1), five male and five female were used to determine the time course and magnitude of arterial blood pressure and heart rate changes after a single rapid intravenous injection of diltiazem during anaesthesia, but in the absence of stimulation produced by laryngoscopy for tracheal intubation and surgery. The patients were a mean of 46 years (SEM 3.6) old and weighed 56.8 kg (SEM 2.0). Anaesthesia was induced with thiopentone 5 mg/kg 3 minutes after a precurarizing dose of pancuronium 0.02 mg/kg, and the trachea was intubated after suxamethonium 2 mg/kg. Anaesthesia was maintained with 0.5% enflurane and 50% nitrous oxide (N_2O) in oxygen, and end-tidal CO_2 ($P\text{E}'\text{CO}_2$) was measured by Datex Capnometer. Muscle relaxation was obtained with pancuronium 0.1 mg/kg and ventilation controlled to maintain a $P\text{E}'\text{CO}_2$ within the range 4.0–4.8 kPa. Each patient received 0.2 or 0.3 mg/kg diltiazem hydrochloride in a random order with at least 20 minutes separating each dose, after the blood pressure and heart rate had stabilised. Mean arterial pressure was continuously recorded from a radial artery catheter immediately before (basal) until 10 minutes after diltiazem administration. Heart rate was calculated from a

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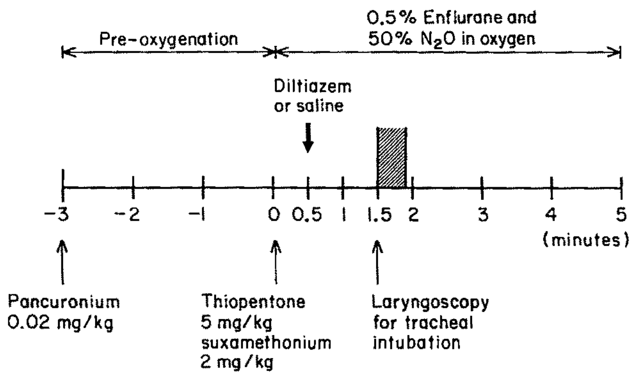
Pre-oxygenation
0.5% Enflurane and 50% N_2O in oxygen
Diltiazem or saline
-3
-2
-1
0
0.5
1
1.5
2
3
4
5
(minutes)
Pancuronium 0.02 mg/kg
Thiopentone 5 mg/kg suxamethonium 2 mg/kg
Laryngoscopy for tracheal intubation

Fig. 1. Experimental protocol for second part of the study. Shaded area denotes time of laryngoscopy and tracheal intubation.

15-second portion of the ECG (lead 11). All measurements were completed before skin incision.

The second part of the study used 30 normotensive patients (ASA grade 1) to determine the effect of prior diltiazem treatment on the cardiovascular responses to tracheal intubation. Stoelting[5] reported that arterial pressure typically began to increase about 15 seconds after laryngoscopy and was maximal after 30 to 45 seconds. It was predicted, based on the previously determined time course of pressure changes after diltiazem, that diltiazem administered 1 minute before laryngoscopy was started would match the blood pressure lowering effects of the drug with the onset and duration of elevation produced by laryngoscopy and tracheal intubation.

The patients were randomly divided into three groups of 10 patients each as follows: group A, control group given saline intravenously; group B, diltiazem 0.2 mg/kg intravenously; group C, diltiazem 0.3 mg/kg intravenously. None had received sedatives, antihypertensives or other drugs likely to interfere with this study. Details of the patients are given in Table 1. Premedication consisted of diazepam 0.1 mg/kg by mouth 1 hour and atropine 0.01 mg/kg intramuscularly 30 minutes before induction of anaesthesia. The experimental protocol is shown in Fig. 1. A radial arterial catheter was inserted in the operating theatre under local anaesthesia for continuous monitoring of arterial pressure. Heart rate was calculated from lead II of the ECG. All patients received pancuronium 0.02 mg/kg, and 3 minutes later anaesthesia was induced with thiopentone 5 mg/kg followed by suxamethonium 2 mg/kg to facilitate tracheal intubation, after stabilisation of the arterial blood pressure and heart rate, while breathing 100% oxygen via a mask. Direct laryngoscopy was attempted 1.5 minutes after thiopentone–suxamethonium, and tracheal intubation was completed within 20 seconds in all patients with the aid of a standard Macintosh laryngoscope blade. Either 0.2 or 0.3 mg/kg of diltiazem, or saline (control) was injected 60 seconds (30 seconds after thiopentone–suxamethonium) before direct laryngoscopy was started. All intubations were performed by the first author, who was unaware of the nature of the injection. Ventilation was assisted as required during anaesthesia, or controlled with 0.5% enflurane and 50% N_2O in oxygen and $P\mathrm{E'CO}_2$ maintained between within 4.0 and 4.8 kPa. Mean arterial pressure, heart rate and the rate pressure product were compared among the three groups.

Statistical analysis was by analysis of variance and Student's *t*-test (paired within groups and unpaired between groups). A p value of less than 0.05 was deemed significant.

Results

Figure 2 indicates the time course and magnitude of the mean arterial pressure and heart rate changes after a single intravenous administration of diltiazem in the absence of stimulation produced by laryngoscopy for tracheal intubation and surgery. The magnitude of the pressure after diltiazem was influenced by the dose, but the onset of decrease was not. Mean arterial pressure began to decrease 20–40 seconds after diltiazem and was maximal at 1 minute 30 seconds, with return toward control apparent by 3

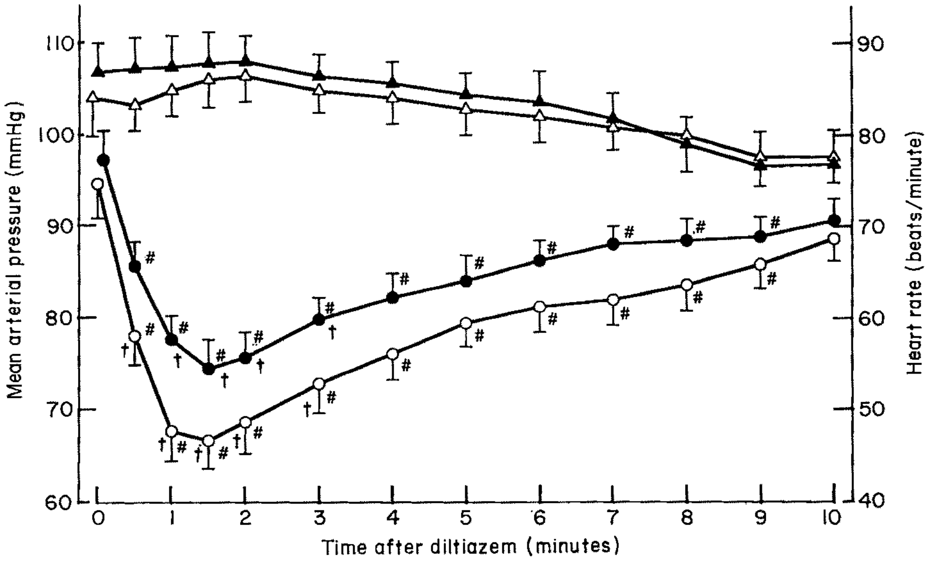

Fig. 2. Changes in mean arterial pressure (MAP) and heart rate (HR) (mean, SEM) after a single rapid intravenous injection of 0.2 mg/kg (●, ▲) and 0.3 mg/kg (○, △) of diltiazem without concomitant laryngoscopy for intubation or surgery. #$p < 0.05$ compared with basal value; †$p < 0.05$ for 0.2 mg/kg compared with 0.3 mg/kg.

Table 1. Demographic data of patients in the second part of the study. Values are expressed as mean (SEM).

	Control (saline)	0.2 mg/kg diltiazem	0.3 mg/kg diltiazem
Patients (*n*)	10	10	10
Male : female	6:4	5:5	5:5
Age, years	48.9 (3.5)	47.5 (3.1)	45.4 (3.8)
Weight, kg	55.9 (3.2)	54.1 (3.9)	57.2 (3.1)

$p > .05$.

minutes and complete after 10 minutes (Fig. 2). Heart rate did not change significantly after injection of either dose of diltiazem.

The three groups of the second study were comparable in respect of age, weight and gender, as shown in Table 1. There was no significant difference among the three groups in mean arterial pressure 10 seconds before the start of laryngoscopy, or at the pre-induction time, as shown in Figure 3. Mean pressure increased significantly in the control group, in response to laryngoscopy and intubation, while the increase was significantly less in the diltiazem-treated groups. Administration of 0.3 mg/kg diltiazem had a greater inhibitory effect on the increase in blood pressure associated with intubation than did 0.2 mg/kg. There was an increase in heart rate after induction and immediately after laryngoscopy and tracheal intubation in the three groups, but there was no significant difference in the pre-induction value for heart rate or that immediately before laryngoscopy and intubation among the three groups (Fig. 4).

Heart rate after intubation was comparable among the three groups, but the rate pressure product was significantly lower in diltiazem-treated groups compared with control, after laryngoscopy and intubation (Fig. 5). Diltiazem 0.3 mg/kg also had a greater inhibitory effect on the increase in rate pressure product after intubation than did 0.2 mg/kg.

No abnormal changes in the ECG were observed in any patient who received diltiazem, although a patient in the control group had ventricular premature contractions. No patients had severe hypotension that required treatment during this study.

Discussion

Diltiazem, a new calcium entry blocker with potent vasodilatory and hypotensive properties, has been used for treatment of hypertension and angina pectoris.[9] There are few adverse reports about this agent. The mechanism of the vasodilator and negative chronotropic action is considered to be by means of interference with Ca^{2+} influx.[9] An intravenous preparation has recently become available and to our knowledge no reports on the effect of diltiazem on cardiovascular changes after tracheal intubation are published.

This study has confirmed previous work that intubation of the trachea after thiopentone and a neuromuscular blocking agent is associated with significant increases in heart rate and mean arterial pressure. Diltiazem at doses of 0.2 and 0.3 mg/kg attenuated the increases in blood pressure and rate pressure product after tracheal intubation compared with a control group, and the inhibitory effect was greater at doses of 0.3 mg/kg.

Diltiazem, as with other vasodilators, failed to prevent

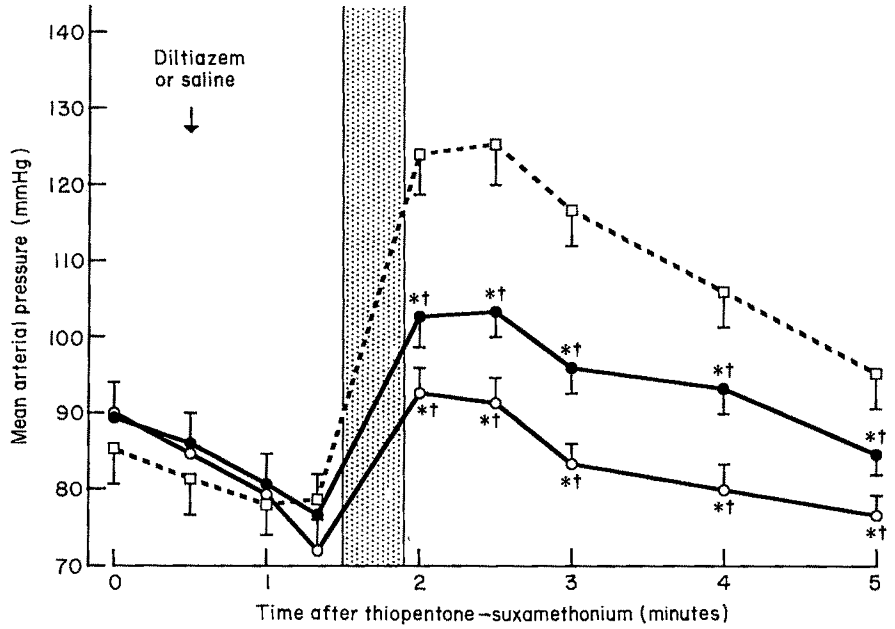

Fig. 3. Changes in mean arterial pressure (mean, SEM) after thiopentone–suxamethonium and in response to laryngoscopy and tracheal intubation with prior diltiazem or saline (control). Shaded area denotes duration of laryngoscopy and tracheal intubation. $*p < 0.05$ compared with control; $\dagger p < 0.05$ for 0.2 mg/kg compared with 0.3 mg/kg. □, control (saline); ●, 0.2 mg/kg diltiazem; ○, 0.3 mg/kg diltiazem.

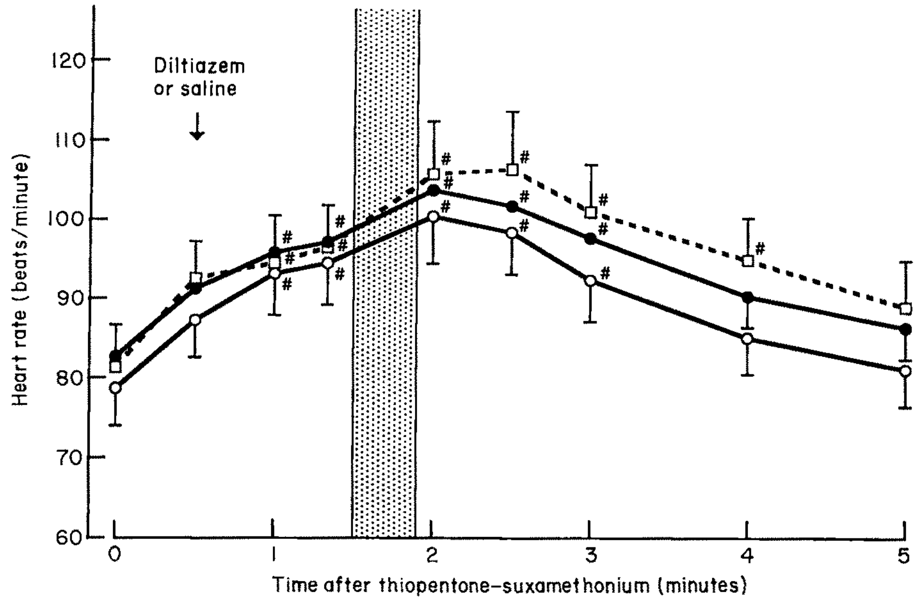

Fig. 4. Changes in heart rate (mean, SEM) after thiopentone–suxamethonium and in response to laryngoscopy and tracheal intubation with prior diltiazem or saline (control). The shaded area denotes duration of laryngoscopy and tracheal intubation. There was no difference among the three groups at any point. #$p < 0.05$ compared with basal value within group. □, control (saline); ●, 0.2 mg/kg diltiazem; ○, 0.3 mg/kg diltiazem.

the tachycardia caused by laryngoscopy and intubation, despite the direct negative chronotropic effect of the agent. This seems to be because the negative chronotropic effect, which is similar to that of verapamil, was masked by sympathetico-adrenal reflex stimulated by hypotension produced by vasodilatation.

The onset and duration of action of diltiazem are rapid and short, as Figure 2 indicates, similar to those with other calcium antagonists. Profound hypotension did not occur in any patient regardless of the dose of diltiazem and it therefore seems to be one of the most appropriate drugs to attenuate the cardiovascular responses to tracheal intubation.

Diltiazem also possesses the ability to dilate coronary arteries and increase coronary blood flow.[10] The rate pressure product showed an attenuated response after diltiazem; the maximum mean value after intubation in those who received 0.3 mg/kg was 11 914. This value is similar to that after nifedipine treatment,[7] but it compares favourably with the values of 17 916 and 15 868 in response

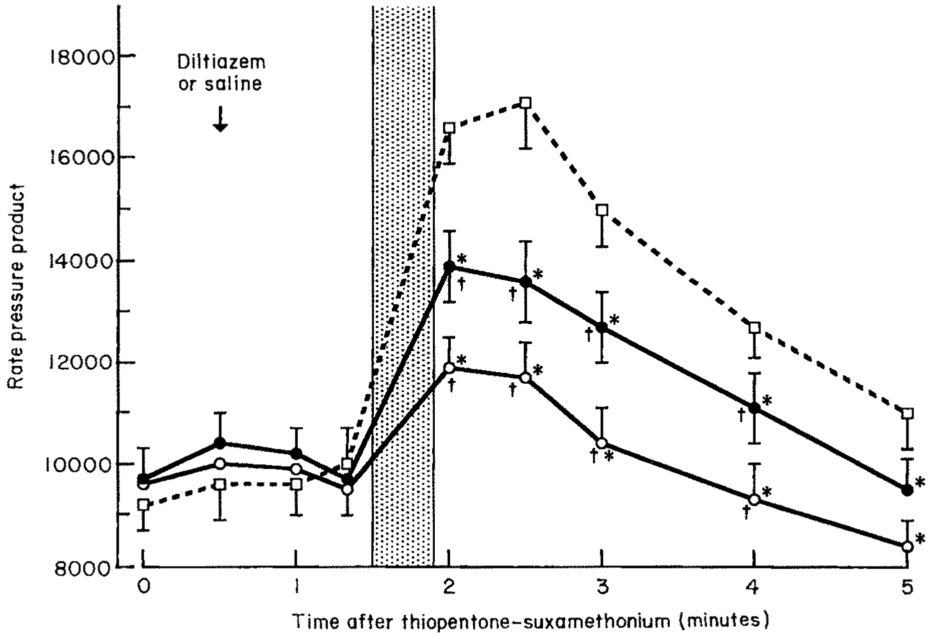

Fig. 5. Changes in rate pressure product (mean, SEM) after thiopentone–suxamethonium and in response to laryngoscopy and tracheal intubation with prior diltiazem or saline (control). The shaded area denotes duration of laryngoscopy and tracheal intubation. *$p < 0.05$ compared with control; †$p < 0.05$ for 0.2 mg/kg compared with 0.3 mg/kg. □, control (saline); ●, 0.2 mg/kg diltiazem; ○, 0.3 mg/kg diltiazem.

to intubation in patients given hydralazine and buprenorphine before induction, respectively.[11,12]

In conclusion, we have shown that a single rapid intravenous injection of diltiazem is a practical pharmacological and safe method to attenuate the hypertensive response to tracheal intubation. We recommend the use of 0.3 mg/kg diltiazem as a supplement during induction to reduce the pressor response to intubation. However, the role of this technique to suppress pressor responses in the patients with hypertension or coronary heart disease at the time of intubation requires further study.

Acknowledgments

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Anaesthesia, 1990, Volume 45, pages 294–296

The effects of propofol and thiopentone on forearm circulation

K. McKEATING, J. P. HOWE AND L. McARDLE

Summary

Some effects of propofol and thiopentone induction on the peripheral circulation of healthy patients are examined using mercury strain gauge venous occlusion plethysmography of the forearm. Results indicate that both drugs produce a statistically significant decrease in mean arterial blood pressure and forearm blood flow. Forearm vascular resistance remains unchanged after either drug. These data suggest that bolus dose induction of anaesthesia with propofol does not cause arterial vasodilatation of the limb and that a cause for the reduction in mean arterial pressure must be sought elsewhere.

Key words

Anaesthetics, intravenous; thiopentone, propofol.
Blood; flow.

Drugs used in anaesthetic practice are known to produce peripheral circulatory effects. The most notable example of these, the inhalational anaesthetic agents, have been studied extensively by McArdle and colleagues using the noninvasive technique of venous occlusion plethysmography of the forearm.[1-5] Intravenous induction agents, on the other hand, are not generally regarded as peripheral vasoactive substances and this has been established in respect of thiopentone using the plethysmographic method.[6] Propofol is therefore different, in that it is reported to produce peripheral vasodilatation which is said to account in part for the decrease in systemic blood pressure that accompanies induction of anaesthesia with this agent.[7]

The purpose of this study is to determine whether or not induction of anaesthesia with propofol alters limb blood flow and vascular resistance in a manner consistent with peripheral vasodilatation. Venous occlusion plethysmography in conjunction with a mercury strain gauge is employed for this purpose.[8]

Methods

Forty healthy women aged 20–55 years who had elective minor gynaecological surgery were studied after Medical Research Ethics Committee approval and informed verbal consent. They weighed between 40 and 80 kg, were unpremedicated and not taking any other medication. These patients were randomly allocated to one of two equal groups, to receive respectively propofol 2.5 mg/kg or thiopentone 5 mg/kg for intravenous induction of anaesthesia.

Heart rate and rhythm were displayed continuously (Life-pak 6) throughout the study period. Mean arterial pressure (mmHg) was measured and recorded at 1-minute intervals by automatic oscillotonometer (Datascope Accutorr la). Corresponding forearm blood flow [(ml blood/100 ml tissue)/minute] and forearm vascular resistance (R units) measurements were made and recorded at 1-minute intervals in the contralateral arm using the mercury strain gauge and venous occlusion plethysmogram. These four variables are used to describe the peripheral vascular profile of a drug when using this methodology.[1]

A 10-minute period of acclimatisation to the equipment and measurements preceded induction of anaesthesia. The patients breathed 100% oxygen at 8 litres/minute via a Magill system to avoid the introduction of nitrous oxide should manual ventilation of the lungs prove necessary after induction.

Anaesthesia was then induced by injecting the test drug into a large forearm vein contralateral to the plethysmogram over a 20-second period. Values for the four variables were then recorded for a further 3 minutes, while the patient continued to breathe 100% oxygen. The patients within each group acted as their own controls; the control value for each variable was the mean of six consecutive recordings immediately before the induction of anaesthesia. The pre-induction control values for heart rate, mean arterial pressure, forearm blood flow and vascular resist-

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Table 1. Heart rate (beats/minute) and mean arterial pressure (mmHg), before and after propofol and thiopentone administration, mean (SEM).

	Before	After (minutes)		
	(control)	1	2	3
Heart rate				
Propofol	83 (3)	81 (3)	80 (2)	78 (2)*
Thiopentone	82 (3)	88 (3)	85 (3)	84 (3)
Mean arterial pressure				
Propofol	93 (2)	75 (3)**	72 (2)**	70 (2)**
Thiopentone	94 (2)	84 (2)**	82 (1)**	84 (2)**

Significant difference from control: $^*p < 0.05$; $^{**}p < 0.005$.

ance were then compared with postinduction values within each group using repeated measures analysis of variance. Demographic data were analysed using unpaired '*t*' tests, and a probability p of < 0.05 was taken as statistically significant.

Plethysmographic technique. Two inflatable cuffs are placed on the arm under study. The first, the 'occlusion' cuff, is placed around the wrist and inflated to 70–80 mmHg above systolic pressure throughout the study period; its function is to isolate the functionally different vascular bed of the hand from that of the forearm. The second or 'collecting' cuff is placed on the upper arm in the normal sphygmomanometer cuff position and is inflated instantaneously to 50 mmHg for 30 seconds at 1-minute intervals. The collecting cuff when inflated arrests venous outflow from the limb while allowing arterial inflow to continue. This results in a small degree of distension of the forearm which is detected by a mercury-in-silastic strain gauge.

The strain gauge is a mercury-filled, fine-bore silastic tube which encircles the midpoint of the forearm, between the two cuffs, in a double loop and is secured in place by a nonconductive mounting block. The gauge, which is temperature compensated, is connected to an isolating pre-amplifier and amplifier with pen recorder. Inflation of the collecting cuff halts venous outflow and thereby results in a small degree of forearm expansion. This in turn causes a small extension in gauge length with a resultant alteration in the diameter of the mercury column contained within. The electrical resistance of the gauge circuit increases and this is amplified and recorded as a voltage change on the pen recorder. This trace is known as the arterial inflow curve, and forearm blood flow is derived from the tangent of the curve in a manner described elsewhere by McArdle.[3] Forearm vascular resistance is obtained by dividing mean arterial pressure by forearm blood flow and is expressed in notional resistance (R) units.

All measurements were carried out at an ambient temperature of 21–23°C with less than 1° variation during the study period.

Results

Patients in the propofol and thiopentone groups were comparable with respect to age (34 years, SEM 2 and 34 years, SEM 2), weight (60 kg, SEM 2 and 61 kg, SEM 2) and control values for the four variables (Tables 1 and 2).

Heart rate and mean arterial pressure

Mean heart rate tended to decrease after propofol and increase after thiopentone induction, but the only statistically significant change recorded within the groups ($p < 0.05$) was a decrease in heart rate 3 minutes after propofol induction. There was a statistically significant decrease in mean arterial pressure after either drug at all three measuring times ($p < 0.005$, Table 1). All patients given propofol recorded a decrease in mean arterial pressure which was maximal at 3 minutes after injection and averaged 23 mmHg. In the thiopentone group the reduction averaged 12 mmHg, was maximal after 2 minutes and affected 18 of the 20 patients.

Table 2. Forearm blood flow (ml blood/100 ml tissue)/minute, and forearm vascular resistance ('R' units), before and after propofol and thiopentone administration, mean (SEM).

	Before	After (minutes)		
	(control)	1	2	3
Forearm blood flow				
Propofol	6.6 (0.7)	4.8 (0.4)**	4.0 (0.3)**	4.3 (0.2)**
Thiopentone	6.7 (0.5)	5.6 (0.6)*	4.7 (0.5)**	4.7 (0.4)**
Forearm vascular resistance				
Propofol	18.3 (2.0)	19.7 (2.9)	19.0 (2.0)	17.9 (1.3)
Thiopentone	18.5 (2.0)	18.9 (2.4)	21.1 (2.2)	20.7 (1.9)

Significant difference from control: $^*p < 0.05$; $^{**}p < 0.005$.

Forearm blood flow and vascular resistance

Induction with either drug produced a statistically significant decrease in forearm blood flow at all three sampling times (Table 2). Forearm flow decreased below control value at all three recording times in 13 out of 20 patients after propofol injection. The mean maximum decrease was 39% and occurred 2 minutes after induction. Flow decreased below control value in 19 out of 20 patients after thiopentone. The mean maximum decrease was 30% and this also occurred at 2 minutes after induction.

Mean forearm vascular resistance was slightly increased by either drug at 1 and 2 minutes after induction and had regained the control value for the propofol but not the thiopentone group by 3 minutes after injection. These changes are not statistically significant (Table 2).

Comparison between propofol and thiopentone

There were only two statistically significant differences between the two drug groups after induction. At 3 minutes, mean heart rate was lower in the propofol group, 78 compared to 84 beats/minute ($p < 0.05$) and forearm blood flow was also lower in the propofol group, 4.3 compared to (4.7 ml/100 ml tissue)/minute ($p < 0.01$).

Discussion

The forearm of the lean healthy adult is accepted as a useful model for muscle and skin blood flow since these two components constitute more than 90% of the deformable limb volume at its midpoint.[9–11] Venous occlusion plethysmography of the limb is a well tried non-invasive way to study peripheral circulatory effects during anaesthesia.[1–5,12–16] Both plethysmography[6] and heat clearance[17] techniques have in fact been used previously to examine the effect of thiopentone induction on the peripheral vasculature. The results of these studies, a reduction in mean arterial pressure and forearm blood flow but little effect on forearm vascular resistance, are confirmed in part by our findings.

The present study demonstrated that circulatory effects in the forearm are similar after propofol and thiopentone induction. Either drug will cause a reduction in mean arterial pressure with a consequent decrease in forearm blood flow, but neither agent alters forearm vascular resistance. The peripheral vascular profile associated with vasodilating properties, namely a decrease in forearm vascular resistance accompanied by an increase in forearm blood flow for a given mean arterial pressure was not observed after propofol administration. The only previous study employing forearm venous occlusion plethysmography during propofol administration investigated the effects of sedative infusions of the drug on forearm blood flow and resistance during spinal anaesthesia.[18] These workers found that mean arterial pressure and forearm blood flow decreased after spinal anaesthesia and further decreased during propofol infusion. Forearm vascular resistance increased reflexly after spinal anaesthesia but was not significantly changed by the subsequent addition of the propofol infusion. Our own findings suggest that propofol has no effect on the resting vascular tone of the forearm and the above study suggests that it has no effect on the vascular tone of the vasoconstricted forearm.

In conclusion, the findings of this study indicate that induction of anaesthesia with propofol does not cause limb vasodilatation. If propofol administration does cause vasodilatation it must do so at a site other than the forearm, e.g. splanchnic circulation, or alternatively the circulatory effects may not be arterial, but differentially venous, as suggested by Goodchild and Serrao.[19]

Acknowledgments

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Latency of brachial plexus block

The effect on onset time of warming local anaesthetic solutions

P. J. HEATH, G. S. BROWNLIE AND M. J. HERRICK

Summary

A double-blind study was set up to investigate the effect of warming local anaesthetic solutions on the latency of onset of subclavian perivascular brachial plexus blocks. Twenty-four adult patients were randomly allocated into two equal groups. In group A the local anaesthetic was injected at room temperature, while in group B the local anaesthetic solution was prewarmed to 37°C in a thermostatically controlled heating block. All blocks were performed using 0.5 ml/kg of a solution prepared by mixing equal volumes of 0.5% bupivacaine with adrenaline 1:200 000, and 1% prilocaine. The speed of onset of sensory blockade was significantly increased when the temperature of the local anaesthetic solution was increased to 37°C. There were no adverse side effects in either group.

Key words

Anaesthetic techniques, regional; brachial plexus block.
Anaesthetics, local; latency.

Successful brachial plexus block provides excellent surgical conditions for unilateral upper limb surgery. It has definite advantages over general anaesthesia since minor sequelae, such as drowsiness and nausea, are avoided, and the technique may provide prolonged postoperative analgesia. One of the main disadvantages of brachial plexus anaesthesia is the long latent period before a satisfactory block is attained. The length of this period varies with the local anaesthetic used. This was reported as an average of 14 minutes, for supraclavicular brachial plexus blocks, using 1% lignocaine hydrochloride or 23 minutes with 0.25% bupivacaine hydrochloride.[1]

The latent period of both bupivacaine hydrochloride and carbonated lignocaine, when used for epidural anaesthesia, may be markedly reduced by warming the local anaesthetic solution to 36–37°C.[2,3] However, prewarming of prilocaine was not shown to improve either the speed of onset or quality of the block attained, when used for intravenous regional anaesthesia.[4] The present study was designed to assess whether this method could be used to shorten the onset time of brachial plexus blocks in a series of patients who presented for orthopaedic surgery of one arm or hand.

Methods

Twenty-four adult patients who presented for unilateral upper limb orthopaedic surgery were studied. Patients with a history of epilepsy, a sensitivity to amide local anaesthetic agents, or who expressed a preference for general rather than regional anaesthesia were not studied. Local district ethics committee approval was obtained and all patients gave written informed consent.

The patients were randomly allocated into one of two groups. Those in group A received the local anaesthetic solution at room temperature, whilst the local anaesthetic solution administered to those in group B was warmed to 37°C using a thermostatically controlled heating block (BT1-19, Grant Laboratory Equipment). All brachial plexus blocks were performed by one of the investigators and assessed by another. Neither the patient nor the anaesthetist who made the assessments was informed of the temperature of the local anaesthetic solution injected.

All patients were premedicated with temazepam 10–20 mg orally 1–2 hours before operation. Venous access was secured in the dorsum of the contralateral hand, on arrival in the anaesthetic room. All blocks were performed with a short-bevelled 22-gauge regional block needle using the subclavian perivascular technique described by Winnie.[5] Correct placement of the needle was confirmed by eliciting parasthesiae below the shoulder. Local anaesthetic solution 0.5 ml/kg was injected over a period of 2 minutes after negative aspiration. The local anaesthetic solution used consisted of equal volumes of 0.5% bupivacaine hydrochloride with adrenaline 1:200 000, and 1% prilocaine hydrochloride.

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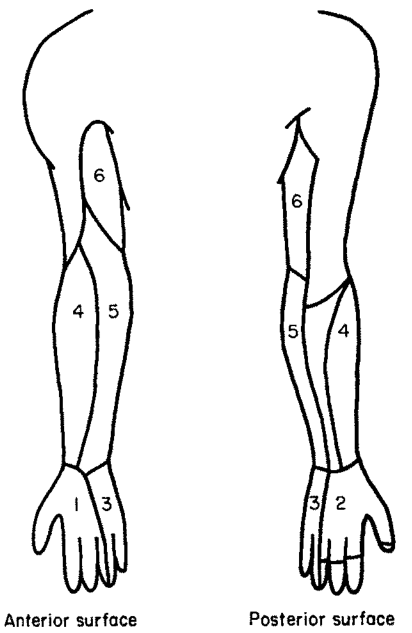

Fig. 1. Cutaneous innervation of the upper limb. 1, median nerve; 2, radial nerve; 3, ulnar nerve; 4, lateral cutaneous nerve of forearm; 5, medial cutaneous nerve of forearm; 6, medial cutaneous nerve of arm.

The onset of sensory blockade was defined by the loss of sensation to pinprick using a short-bevelled 22-gauge needle. Assessments were made at 5-minute intervals after completion of the injection of local anaesthetic, until either loss of pinprick sensation was demonstrated, or 30 minutes had elapsed. Sensory testing was carried out in each of six discrete areas that corresponded to the distribution of the major peripheral nerves (Fig. 1). The onset of motor block was assessed by testing power independently in each of six muscle groups, again at 5-minute intervals, after the completion of injection. The movements tested were abduction and adduction at the shoulder, flexion and extension at the elbow, and flexion and extension of the fingers. Motor block was judged to be present when the patient was unable to initiate the relevant movement against gravity.

Age, weight, sex and nature of surgery were recorded for each patient. Statistical analyses, Student's *t*-test, Chi-squared and Fischer's exact test, were used where appropriate. A p value of less than 0.05 was considered statistically significant.

Table 1. Patient data and operations performed.

	Group A (room temperature)	Group B (37°C)
Number of patients	12	12
Age, years, mean (SEM)	48.6 (6.6)	54.5 (4.8)
Weight, kg, mean (SEM)	67.5 (3.8)	63.3 (4.9)
Males/females	6/6	3/9
Operations performed		
Dupuytren's contracture	2	2
Arthrodesis/arthroplasty MCP joint	3	6
Internal fixation fracture	2	0
Excision of tumour	1	1
Miscellaneous	4	3

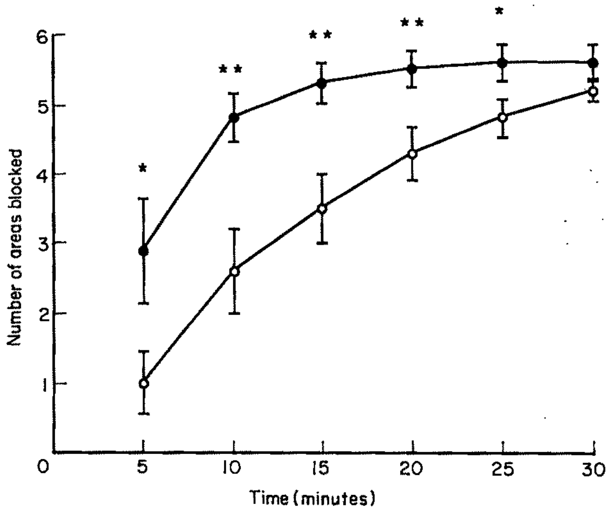

Fig. 2. Spread of analgesia to pinprick. Mean (SEM) number of areas blocked. Significant difference between the groups. *p < 0.05; **p < 0.01. (Student's *t*-test.) -●-, warm; -○-, cold.

Results

There were no statistically significant differences in the demographic characteristics or nature of surgery for the two groups (Table 1).

The rate of spread of analgesia, defined by loss of pinprick sensation, is illustrated in Figure 2. This shows the mean (SEM) number of areas blocked at 5-minute intervals in each of the two groups. The extent of sensory blockade was significantly greater in the group who received warmed local anaesthetic solutions at 5, 10, 15, 20 and 25 minutes after injection. By 30 minutes the extent of sensory blockade was similar for the two groups.

There were marked differences in the success rate and speed of onset of sensory blockade between the six areas tested. A success rate of 100% was obtained for sensory blockade of the lateral cutaneous nerve of forearm. In contrast, a success rate of less than 60% was achieved for sensory blockade of the medial cutaneous nerve of arm (Table 2). Loss of pinprick sensation occurred more rapidly with the warmed local anaesthetic solution in all six areas. This difference reached statistical significance in all areas except the medial cutaneous nerve of arm. The percentage of patients with sensory blockade of at least five out of six areas is plotted against time for each of the two groups in Figure 3. A greater percentage of the patients who received prewarmed local anaesthetic solution showed sensory blockade of five or more areas for all times up to 25 minutes from the completion of injection. This difference was statistically significant at 5, 10 and 15 minutes after injection.

The rate of onset of motor block is illustrated in Figure 4. This shows the mean (SEM) number of muscle groups blocked at 5-minute intervals for the two groups. The extent of motor blockade at each assessment was greater in the group which received prewarmed local anaesthetic solutions. This difference was statistically significant at 10, 15, 20, 25 and 30 minutes after injection. Motor blockade was more common and its onset more rapid with the prewarmed local anaesthetic solutions for all the muscle groups tested (Table 3).

No adverse side effects attributable to the injection of local anaesthetic were observed in either group.

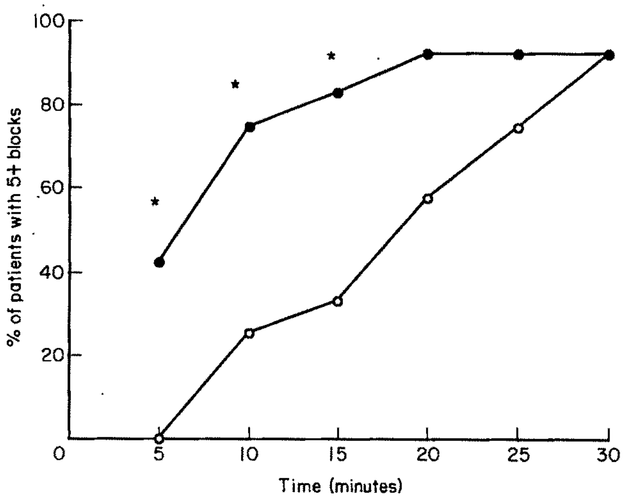

Fig. 3. Spread of analgesia to pinprick. Percentage of patients with five or more areas blocked. Significant difference between the groups. *$p < 0.05$. (Fisher's exact test.) -●-, warm; -○-, cold.

Discussion

In recent years there has been an increasing interest in local anaesthetic techniques. Improved surgical conditions, stress-free anaesthesia, avoidance of toxic effects of inhalational agents and prolonged postoperative analgesia are regarded as some of the advantages.[6]

There remain two main disadvantages to the use of local anaesthetic blocks. A 100% success rate is not invariable even in the best hands, and may be very much lower during the learning period.[7,8] The second problem is that of latency of action. Many local anaesthetic techniques are time consuming in comparison to general anaesthesia. The rate of onset of anaesthesia may be unpredictable and sometimes very slow once the injection has been made. Some anaesthetists overcome the problem of latency delaying surgical lists by grouping the local anaesthetic procedures together. Thus while the surgeon is finishing one case an anaesthetist may be performing a local anaesthetic block for the subsequent case. In the interest of safety, this requires the presence of two anaesthetists allocated to one list. Such practice has been deprecated for the single-handed anaesthetist by both the Harvard group and the Association of Anaesthetists of Great Britain and Ireland.[9,10]

Calculation of the mean number of sensory areas blocked at 5-minute intervals for each of the two groups clearly demonstrates the superiority of the prewarmed local anaesthetic solution (Fig. 2). A significantly greater number of areas were blocked in the group who received prewarmed local anaesthetic solutions at 5, 10, 15, 20, and 25 minutes after completion of injection. The delay before surgery is allowed to start is of more direct relevance to the practising anaesthetist. A sensory blockade of five out of six areas would almost invariably be sufficient for surgery to commence. Over 80% of those in the group who received prewarmed local anaesthetic solution showed sensory blockade of at least five areas within 15 minutes from the completion of injection; and in almost 50% this was achieved within 5 minutes (Fig. 3). Over 25 minutes had elapsed before 80% of patients showed sensory blockade of five or more areas in the group who received room-temperature local anaesthetic solution; and in no patient was this extent of sensory blockade achieved within 5 minutes. These results indicate that the time until an

Table 2. Onset of sensory block.

	% of areas blocked at 30 minutes		Onset of sensory block in minutes mean (SEM)		Mean onset time of group B as % of group A
	Group A room temperature	Group B 37°C	Group A room temperature	Group B 37°C	
Median	92	100	11.8 (1.39)	8.3 (1.12)*	71
Radial	92	100	15.9 (2.60)	7.9 (0.96)**	50
Ulnar	92	92	15.0 (2.02)	8.2 (1.82)*	55
LCFA	100	100	16.3 (2.62)	10.0 (1.63)*	62
MCFA	100	92	13.8 (2.47)	6.8 (0.76)**	50
MCA	42	75	12.0 (3.39)	10.0 (1.86)	63

LCFA, lateral cutaneous nerve of forearm; MCFA, medial cutaneous nerve of forearm; MCA, medial cutaneous nerve of arm.

Significant difference between the groups. *<0.05; **$p<0.01$ (Student's *t*-test).

Table 3. Onset of motor block.

	% of groups blocked at 30 minutes		Onset of motor block in minutes mean (SEM)		Mean onset time of group B as % of group A
	Group A room temperature	Group B 37°C	Group A room temperature	Group B 37°C	
Abduction shoulder	83	100	15.0 (2.89)	10.0 (1.63)	67
Adduction shoulder	83	100	13.0 (2.26)	8.3 (1.28)*	64
Flexion elbow	58	75	10.0 (1.54)	9.4 (1.00)	94
Extension elbow	75	100	11.1 (2.17)	6.7 (0.71)*	60
Flexion fingers	50	83	13.3 (4.22)	8.0 (1.53)	60
Extension fingers	67	75	14.4 (3.20)	6.7 (0.83)*	46

Significant difference between the groups. *$p<0.05$ (Student's *t*-test).

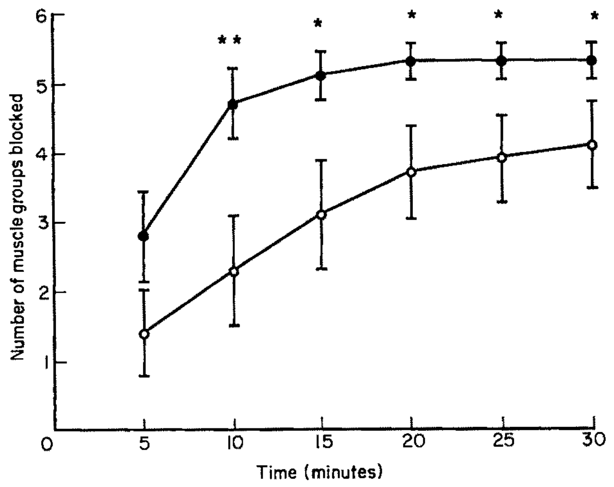

Fig. 4. Spread of motor block. Mean (SEM) number of muscle groups blocked. Significant difference between the groups. $*p < 0.05$; $**p < 0.01$. (Student's *t*-test.) -●-, warm; -○-, cold.

adequate sensory block can be confidently predicted may be reduced by almost 50% by using prewarmed local anaesthetic solutions.

The extent and rate of onset of motor blockade is less important in determining the adequacy of the block for the start of surgery. Nevertheless, calculation of the mean number of muscle groups blocked at 5-minute intervals for each of the two groups confirms the superiority of prewarmed local anaesthetic solutions for motor as well as sensory blockade (Fig. 4).

Many methods have previously been proposed to improve the speed of onset of regional blockade. These have included carbonation,[11,12] the addition of potassium[13] or dextran,[14] pH-adjustment with sodium bicarbonate and the use of local anaesthetic mixtures that contain chloroprocaine.[15] pH-adjustment with sodium bicarbonate has been the most successful of these methods. pH-adjustment of bupivacaine has been shown to reduce latency by up to 50% in studies on epidural analgesia,[16] sciatic nerve block,[17] and brachial plexus block.[18] This is similar to the reduction of latency we have observed after local anaesthetic solutions were prewarmed to 37°C. It is possible that a combination of these two methods would result in an even greater improvement in the speed of onset of anaesthesia.

Prewarming of local anaesthetic solutions is an inherently safe technique provided certain precautions are observed. Heating of bupivacaine or prilocaine to 37°C does not adverely affect the solutions in any way (personal communication, Astra Pharmaceuticals). Dry heating prevents the risk of undetected contamination by water from heating in a water bath, a mechanism of contamination analogous to that proposed in the Woolley and Roe case.[19] It is clearly important to ensure that overheating is not allowed to occur. The temperature of the heating block in this study was thermostatically controlled and the temperature of an ampoule of saline kept in the block was continually monitored to ensure that it did not exceed 37°C. Warming cabinets were rejected as suitable sites to warm local anaesthetic solutions during the prestudy period because the temperature frequently exceeded 60°C.

The mechanism by which prewarming reduces the latency of local anaesthetic solutions is unclear. The onset of conduction block in isolated nerves is determined primarily by the pKa of the individual agents.[20] The reason for this is that the diffusion of local anaesthetics across nerve sheath and membrane is dependant on the presence of the drug in the uncharged, lipid soluble form.[21] Agents with a relatively low pKa and a correspondingly higher proportion of free base therefore exhibit a faster onset. Additionally, the latency of onset may be affected by the rate of diffusion through non-nervous tissues. The change in temperature in this study is small, although it would be expected to enhance the rate of simple diffusion. It is possible that this could have a significant effect on onset time in regions, such as the brachial plexus, where considerable barriers to diffusion exist.

Prewarming of local anaesthetic solutions to 37°C is a simple, safe and effective method to reduce the latency of brachial plexus block. This reduction in latency will be of benefit to all anaesthetists who wish to use this form of anaesthesia.

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Postoperative nefopam and diclofenac

Evaluation of their morphine-sparing effect after upper abdominal surgery

A. C. MOFFAT, G. N. C. KENNY AND J. W. PRENTICE

Summary

The aim of the study was to assess the relative morphine-sparing effects of nefopam and diclofenac when used singly or in combination after upper abdominal surgery. Eighty-four patients of ASA grade 1 or 2 were allocated randomly to one of three groups. Group A received nefopam 20 mg by intramuscular injection 6 hourly after surgery for the 24-hour study period. Group B received diclofenac 75 mg 12-hourly and placebo injections at 6 and 18 hours after surgery. Group C received both 6-hourly nefopam and 12-hourly diclofenac. Supplemental analgesia was given on demand via a patient-controlled analgesia system which delivered intravenous morphine. Morphine requirements in the diclofenac group were significantly lower than in either of the other groups ($p < 0.01$). Patients who received the combination of nefopam and diclofenac required significantly less morphine than those who received nefopam alone ($p < 0.01$). Pain scores assessed 6 hours after surgery were significantly lower in the diclofenac and combination groups compared with the nefopam group ($p < 0.01$).

Key words

Analgesia; postoperative.
Analgesics; nefopam, diclofenac, morphine.

Traditionally, on-demand intramuscular injections of opioids have been used to provide postoperative analgesia after major abdominal surgery. However, many patients may still have inadequate pain relief.[1–3] This may be due either to delays in administration of the opioids, to pressure of work on nursing staff or to a reluctance to administer the drugs on demand in sufficient doses because of fear of associated side effects.[4] Consequently, there is renewed interest in the use of nonopioid analgesics. The aim of using such drugs is to reduce the requirements for opioids, and thereby the frequency of unwanted side effects, but to improve the quality of pain relief.

A recent study has shown that nefopam hydrochloride has a significant morphine-sparing effect;[5] Morphine requirements were reduced by 30% when nefopam 20 mg was administered pre-operatively and 6-hourly postoperatively after upper abdominal surgery. A similar study compared the use of a placebo with diclofenac sodium 75 mg given 12-hourly after surgery.[6] This showed that diclofenac reduced morphine consumption by one third. Nefopam hydrochloride is a centrally-acting compound which is related structurally to diphenhydramine and orphenadrine.[7,8] Its exact mode of action remains unclear. It is known to inhibit the neuronal uptake of noradrenaline, dopamine and serotonin and is thought to increase neurotransmission in pain inhibitory pathways.[9] Diclofenac sodium is a phenylacetic acid derivative. It is a nonsteroidal anti-inflammatory agent with significant analgesic properties.[10] It acts peripherally by inhibiting prostaglandin synthetase. Nefopam and diclofenac have different sites and modes of action, and the question is whether the combination of the two drugs would have a greater analgesic effect than either drug used individually. The aim of this study was to assess this possibility.

Methods

Hospital ethics committee approval was obtained for the study and informed written consent obtained from 84 patients scheduled to undergo elective upper abdominal surgery. All patients were of ASA grade 1 or 2, aged between 18 and 70 years and weighed between 45 and 100 kg. Patients were not studied if they suffered from significant cardiovascular, respiratory, hepatic, renal or haematological disorders. Patients with a history of allergy to aspirin or other nonsteroidal anti-inflammatory agents, and those receiving medication likely to influence anaesthetic or analgesic requirements, were also excluded from the study.

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Table 1. Comparison of groups. Data are presented as mean (SD).

	Nefopam ($n=28$)	Diclofenac ($n=28$)	Both ($n=28$)
Male/female	11/17	10/18	10/18
Age, years	46 (13)	51 (12)	47 (14)
Weight, kg	66 (13)	67 (14)	68 (12)

No significant differences among groups.

A standardised anaesthetic technique was used. This included premedication with temazepam 20–30 mg orally and induction with sodium thiopentone. Anaesthesia was maintained with isoflurane and nitrous oxide in oxygen with vecuronium as the neuromuscular blocking agent. Increments of intravenous morphine were given for intraoperative analgesia.

Patients were allocated randomly to one of three groups. Group A received nefopam 20 mg intramuscularly after surgery and 6-hourly thereafter. Group B were given diclofenac 75 mg intramuscularly postoperatively and 12 hours later; these patients were also given a placebo injection at 6 and 18 hours after surgery. Group C received both 6-hourly nefopam and 12-hourly diclofenac. In addition, all patients were provided with a patient-controlled analgesic system programmed to deliver 1 mg of morphine on demand with a 3-minute lock-out period. The pattern of morphine use and the total morphine requirements for the 24-hour study period were noted.

Pain levels were assessed at 6 and 24 hours after operation using visual analogue scales (100-mm line) and verbal scoring (0 = no pain, 1 = mild, 2 = moderate, 3 = severe). Sedation levels at these times were also ranked (0 = fully awake, 1 = drowsy, 2 = asleep but responds to gentle stimulus, 3 = does not respond to gentle stimulus). The incidences of adverse effects such as nausea, vomiting and urinary retention and the frequency of metoclopramide administration were recorded.

Statistical analysis of the demographic data was performed using unpaired t-tests. Nonparametric data were analysed by Mann–Whitney U tests.

Results

Eighty-four patients were entered into the study. The groups were comparable in terms of age, weight and sex (Table 1). There were no significant differences either in duration of surgery or intra-operative morphine consumption; all groups received a mean morphine dose of 13–14 mg (Table 2). The pattern of morphine consumption over the 24-hour study period and the totals for each group are shown in Table 3 and Figure 1. The highest morphine requirements in each group were in the first 6-hour period. The morphine use within each group then continued at a steady rate over the next three 6-hour periods. The total morphine consumption over 24 hours was significantly lower in the diclofenac group (30 mg) compared with both the combination group (38 mg) and nefopam alone (52 mg) ($p < 0.01$). The combination group also used significantly less morphine than the nefopam group ($p < 0.01$).

Table 2. Premedication and intra-operative details. Data are presented as mean (SD).

	Nefopam ($n=28$)	Diclofenac ($n=28$)	Both ($n=28$)
Morphine consumption in theatre (mg)	13 (5)	13 (3)	14 (3)
Operative duration (minutes)	87 (39)	89 (33)	85 (41)

No significant differences among groups.

Table 3. 24-hour morphine consumption (mg). Data are presented as mean (SD).

Time (hours)	Nefopam ($n=28$)	Diclofenac ($n=28$)	Both ($n=28$)
0–6	20 (12)	15 (10)	14 (7)
6–12	11 (7)	5 (6)	8 (6)
12–18	10 (9)	5 (4)	8 (7)
18–24	11 (8)	6 (6)	8 (5)
Total	52 (28)*	30 (20)**	38 (20)

*Significant differences between nefopam and both diclofenac and combination groups ($p<0.01$).

**Significant difference betwen diclofenac and combination groups ($p<0.01$).

Table 4 shows the results of the pain and sedation scores. Visual analogue scales and verbal pain scores were significantly lower in the diclofenac and the combination groups compared with the nefopam group when assessed 6 hours after surgery ($p < 0.01$).

There were no significant differences in the pain scores by 24 hours or in the sedation scores either at 6 or 24 hours. The frequency of side effects is shown in Table 5. The incidences of nausea, vomiting and urinary retention were similar in the three groups as was the frequency of metoclopramide administration. There were no episodes of respiratory depression and no patients complained of discomfort associated with the injection sites.

Discussion

Most patients are prescribed intermittent intramuscular opioids on demand for pain relief after abdominal surgery.[11] The quality of analgesia obtained is inadequate for many of these patients. One reason that patients receive insufficient opioids is the fear of respiratory depression. Nonopioid analgesics do not cause this side effect. Regular doses of such agents may enable the total dose of opioid

Table 4. Pain and sedation scores. Data are presented as mean (SD).

	Nefopam ($n=28$)	Diclofenac ($n=28$)	Both ($n=28$)
Visual analogue scales (mm)			
6 hours	38 (22)*	26 (23)	28 (20)
24 hours	28 (21)	19 (14)	28 (23)
Verbal pain scores			
6 hours	1.5 (0.8)*	1.0 (0.6)	1.1 (0.6)
24 hours	1.1 (0.9)	0.8 (0.5)	0.7 (0.7)
Sedation levels			
6 hours	1.2 (0.6)	1.0 (0.8)	1.1 (0.7)
24 hours	0.1 (0.4)	0.1 (0.3)	0.1 (0.3)

*Significant differences between nefopam and both diclofenac and combination groups ($p<0.01$).

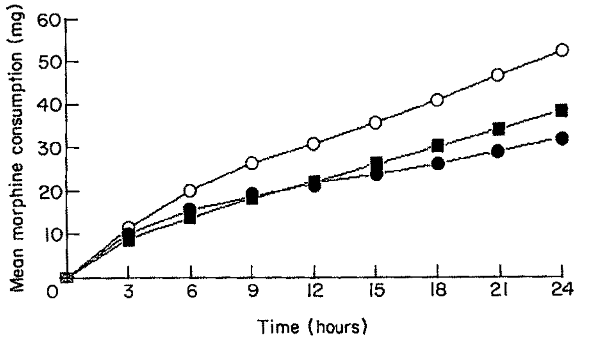

Fig. 1. 24-hour morphine consumption. ○, nefopam; ●, diclofenac; ■, both.

Table 5. Frequency of side effects and metoclopramide administration.

	Nefopam ($n=28$)	Diclofenac ($n=28$)	Both ($n=28$)
Nausea	13	8	13
Vomiting	5	6	5
Urinary retention	5	7	5
Metoclopramide	8	5	9

No significant differences between groups.

required to be reduced. This would decrease the risk of respiratory depression but should increase the proportion of patients who receive adequate postoperative analgesia.

Most nonopioid analgesics are thought to act at the level of the peripheral sensory receptor.[12] However, nefopam hydrochloride acts centrally at spinal and supraspinal levels.[13] The aim of the study was to establish whether the use of nefopam combined with a peripherally acting analgesic such as diclofenac would have a greater analgesic effect than either of the drugs used individually.

The results indicate that although the combination of nefopam and diclofenac does have a greater morphine-sparing effect than nefopam alone, it is not as effective as diclofenac alone. It is not clear why this is so. It may be that although they act at different sites there is still some antagonism between nefopam and diclofenac. Alternatively, the addition of a third analgesic drug may alter plasma protein binding of the analgesics and therefore change the proportion of drug which is unbound.

Significantly lower pain scores by both visual analogue scales and verbal scoring occurred in the diclofenac and combination groups 6 hours after surgery compared with the nefopam group. This suggests that these groups achieved better analgesia while consuming less morphine. Nefopam is a weak central stimulant.[14] This action may make patients more aware of their pain at a time when there are still some residual effects of anaesthesia. However, the stimulating action of nefopam was not reflected in significantly different sedation levels between the groups.

Nausea is a common side effect of nefopam, but there were no significant differences in the incidences of nausea or in the frequency of metoclopramide administration among the groups.

Some patients were excluded from the study on the grounds of age, weight, coexisting pathology or current drug administration, in order to standardise the study as much as possible, since these factors are known to influence drug requirements. A separate placebo group was not included in the study because it has already been established that nefopam and diclofenac have a morphine-sparing effect.[5,6] The two placebo groups in these studies, which also assessed morphine requirements after abdominal surgery, consumed 62.5 mg and 59 mg of morphine respectively over the 24-hour study period. This compares with 52 mg for the nefopam group, 38 mg for the combined group and 30 mg for the diclofenac group in the present study.

The study became open when the patients had been allocated randomly to the groups. This is not thought to have affected the results since the patients themselves remained unaware which drugs they received. All patients were given 6-hourly intramuscular injections, and the use of a patient-controlled analgesic system to assess additional analgesic requirements removes observer bias.

We conclude that the combination of nefopam and diclofenac confers no benefit over the use of diclofenac alone. However, the results emphasise the significant reduction in morphine requirements that can be achieved with the use of nonopioid analgesics such as diclofenac.

Acknowledgments

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Anaesthesia, 1990, Volume 45, pages 306–308

Postoperative sore throat

A comparison after premedication with papaveretum/hyoscine or temazepam

S. VALENTINE, F. K. McVEY AND A. COE

Summary

A randomised double-blind trial was conducted to study the use of two commonly used premedication regimens and the subsequent incidence of sore throat. Fifty adult patients who underwent routine surgery were anaesthetised in a standard fashion after premedication with papaveretum and scopolamine or temazepam, and interviewed after operation to assess the presence of sore throat. A significantly higher incidence of sore throat was associated with the use of papaveretum and scopolamine.

Key words

Premedication; papaveretum, hyoscine, temazepam.
Complications; sore throat.

Sore throat is a common postoperative complaint. The incidence varies from 5 to 90%, and the condition occurs most frequently in patients whose trachea has been intubated.[1,2] Many other factors, including use of lubricants,[2,3] pharyngeal packs,[2,4] and type of tracheal tube[3-6] have been implicated. It is possible that the mucosal drying effect of anticholinergic premedication might increase the incidence of throat dryness and discomfort,[7] but we could find no data in the literature on this specific question. However, anticholinergic premedication is in such widespread use that the findings would be relevant to routine anaesthetic practice. The aim of this study was to compare two commonly used premedication regimens, one of which contained an anticholinergic agent, on the incidence of postoperative dry and sore throat.

Method

The local ethics committee approved the study. Fifty adult patients scheduled to undergo surgery that required tracheal intubation and mechanical ventilation in the supine position were studied. Patients were excluded if there was a pre-existing sore throat or upper respiratory tract infection, or if dental, ear, nose and throat, or neck surgery was planned. Eligible patients were allocated randomly to one of two groups by tossing a coin.

Group one received papaveretum 10 to 20 mg with hyoscine 0.2 to 0.4 mg intramuscularly depending upon body weight, one hour before operation. Group two received temazepam 10 to 30 mg orally one hour before operation. Both regimens are in routine practice, and nursing staff and patients were not informed of the trial or its purpose.

All patients were anaesthetised in a standardised fashion. General anaesthesia was induced with thiopentone 3–5 mg/kg and the patient was paralysed with vecuronium 0.1 mg/kg. The trachea was intubated with a red rubber cuffed oral Magill tube (8.0 mm internal diameter for females and 9.0 mm internal diameter for males). All tracheal tubes were lubricated with K-Y jelly. Any patient who required more than one laryngoscopy to effect intubation was excluded. The cuff of the tracheal tube was inflated with air until a seal was just achieved and then readjusted if a leak occurred later.

Anaesthesia was maintained with 66% nitrous oxide in oxygen, and isoflurane. Analgesia was provided by fentanyl 1–3 μg/kg. Supplemental doses of vecuronium were given as required. Any change in the patient's position from supine, or the insertion of a nasogastric tube or pharyngeal pack, led to exclusion from the trial.

Muscular relaxation was reversed at the end of surgery in all cases with atropine 20 μg/kg and neostigmine 40 μg/kg. Pharyngeal secretions were sucked clear with a plastic Yankauer sucker and the patient's trachea was extubated after return of spontaneous ventilation. A Guedel airway was inserted after extubation and removed when no longer tolerated by the patient.

Both groups were prescribed papaveretum and metoclopramide as required postoperatively.

A second investigator, unaware of the premedication given, interviewed the patients between 12 and 24 hours later using a standardised interview format that employed

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Table 1. Interview format.

'Hello, I'm Dr , an anaesthetist. I've come to see how you are after your general anaesthetic.'

1. 'How are you feeling?'
2. 'Do you have any discomfort or pain? If so whereabouts and how would you describe it?' This question was repeated until all complaints had been elicited.
3. 'Do you have or have you had a dry or a sore throat?'
4. 'Do you smoke at all? How many?'

both indirect and direct questions (Table 1). Each interview was conducted as privately as possible in the ward setting. After a general introduction, the patients were asked if they had any pain or discomfort anywhere. They were then asked directly if a dry or painful throat was present. The patients' responses were recorded immediately on a form designed for that purpose. Statistical analysis was performed using Student's *t*-test, Chi-square test and Fisher's exact test, as appropriate.

Results

The general characteristics of the 50 patients and the nature of their operations are shown in Table 2. There are no significant differences between the groups in terms of gender, age, smoking habits, duration of anaesthesia or peri-operative fluids received.

The incidence of sore throat in patients who received papaveretum and hyoscine premedication was 38% (95% confidence intervals (CI) 19–57%) on indirect questioning, and 67% (95% CI 45–85%) on direct questioning. In contrast, only 19% (95% CI 7–40%) of patients who were premedicated with temazepam had a dry throat on direct questioning only, and none complained of a sore throat. This difference is statistically significant for both direct questioning ($p < 0.01$) and indirect questioning ($p < 0.01$; Table 3). No patient who smoked complained of a dry or painful throat after operation.

Discussion

Our results show that there is a significant degree of postoperative throat discomfort, either soreness or dryness, associated with intramuscular opiate and anticholinergic premedication up to 24 hours after surgery. The groups were well matched for age, sex and duration of operation. Anaesthetic and interview technique were standardised to minimise the effects of other factors implicated in the genesis of sore throats.

Table 2. General characteristics of patients and nature of operations.

	Group 1 ($n = 24$)	Group 2 ($n = 26$)
Male : female	10:14	11:15
Mean age, years (SD)	44 (16)	53 (19)
Smokers (more than 5 cigarettes daily)	7	6
Peri-operative fluids		
Number receiving	15	11
Volume, ml, mean (SD)	1717 (589)	1682 (815)
Operations		
Orthopaedic	11	11
General surgical	8	8
Gynaecological	5	2
Ophthalmological	—	5
Duration		
Minutes, mean (SD)	81(48)	76 (35)

Group 1, papaveretum and hyoscine; Group 2, temazepam.

Table 3. Incidences of dry or painful throat on indirect (direct) questioning.

	Nil	Dry	Pain	Total
Group 1	15 (8)	7 (10)	2 (6)	24
Group 2	26 (21)	0 (5)	0 (0)	26

$p < 0.01$ for both direct and indirect questioning.
Group 1, papaveretum and hyoscine; Group 2, temazepam.

Throat discomfort contributes to the physical ailments suffered by the postoperative patient. In 1960, an editorial called for increasing recognition of minor sequelae of anaesthesia and greater efforts to reduce their incidence.[8]

The use of anticholinergic drugs in anaesthetic practice began in 1861 to counteract the excessive respiratory tract secretions during open-drop ether anaesthesia, and remains in widespread use. A survey in 1978 found that 62.7% of anaesthetists in UK used anticholinergic premedication routinely.[9] Suggested beneficial properties of anticholinergic premedication include protection against vagal overactivity, an antiemetic action, amnesia, sedation and reduced incidence of hiccups.[10] Falick[11] found that premedication with glycopyrronium significantly decreased the occurrence of complications due to respiratory tract secretions and advocated the continued use of anticholinergic premedication.

Holt[12] and later Gravenstein and Anton[13] suggested avoidance of anticholinergic premedication for minor surgical procedures, and studies by Kessell,[14] and Leighton and Sanders,[15] showed no adverse effects from omission of routine anticholinergic premedication.

The incidence of sore throat after anaesthesia varies between 5 and 100%.[2,4,16–20] Hartsell and Stephen[16] found that only 5% of patients volunteered the complaint, and that sore throat was rarely a primary complaint during the interview. However, Cronin *et al.*[19] found that more than half of all general surgical patients complained of some degree of sore throat; 6% of these regarded it as the most unpleasant part of their recovery. Similarly Edmonds-Seal *et al.*[4] found that 38% of intubated patients complained of sore throat and almost all patients in his series had a dry mouth which was 'often distressing to the patient.' Antisialagogues had been used and the patients were relatively dehydrated.

Many factors affect the incidence, including the interview method used, to elicit the complaint.[20] Intubation of the trachea is associated with approximately a four-fold increase of sore throat in many studies.[2,4,16] The size and shape of the tracheal tube, and the size, shape and pressure of the cuff have been studied with varying conclusions.[2,3,5,6,18,21] Lubricants appear to make little difference to the incidence, but those that contain a local anaesthetic may make the problem worse.[3,16,18,22] Use of suxamethonium with subsequent myalgia is associated with sore throat.[23] Other factors include use of a pharyngeal pack,[2] nasogastric tube,[2,16,18] movement of the head during surgery,[18,24] straining on the tracheal tube, and the prone position.[4,18] As far as possible, these factors were standardised in the present study and we believe that the difference between the groups was the result of inclusion of hyoscine in premedication of patients in group 1.

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Anaesthesia, 1990, Volume 45, pages 309–310

CASE REPORT

Retroperitoneal fibrosis after multiple coeliac plexus blocks

J. PATEMAN, M. P. WILLIAMS AND J. FILSHIE

Summary

Retroperitoneal fibrosis is described as a complication of multiple coeliac plexus blocks for chronic pancreatitis.

Key words

Anaesthestic techniques; regional, coeliac plexus.
Complications; fibrosis, retroperitoneal

Computerised axial tomography (CT) is an effective guidance technique for unilateral and bilateral coeliac plexus block.[1] We describe a case of a patient who underwent multiple coeliac plexus blocks in whom placement of the needle became progressively more difficult. CT control proved helpful in explaining the cause of the difficulty and assisted initially in the successful placement of a contralateral block.

Case history

The patient was a 44-year-old man with a 21-year history of chronic relapsing pancreatitis. He had a distal pancreatectomy and pancreaticojejunostomy, but unfortunately this had only given temporary relief of symptoms.

He was treated, over a 3-year period, with nine coeliac plexus blocks under CT control, seven bilateral and two left-sided unilateral blocks. A mixture of 50% alcohol and either methyl prednisolone or dexamethasone were injected on each occasion and satisfactory analgesia was obtained postoperatively for periods that ranged from 2 to 6 months. It became progressively more difficult to enter a satisfactory plane for injection and on the eighth and ninth occasions it proved impossible to enter a plane for injection on the left side.

A comparison of his CT scans obtained at this time and at the time of the first coeliac plexus block provides an explanation for the difficulty. The scan at his first block shows a clear retroperitoneal fat plane to the left of the aorta at the level of the left renal vein (Fig. 1a).

A corresponding CT section obtained on the occasion reported showed complete obliteration of this retroperitoneal fat plane and its replacement by an irregular plaque of dense soft tissue (Fig. 1b). The CT did, however, show that a satisfactory fat plane existed on the right, one section cranially. A unilateral right-sided block was suggested and with CT guidance was satisfactorily achieved. Ultimately it became impossible, even with CT guidance, to find an appropriate plane for the injection of a neurolytic agent on either the left or right. The patient has since had to rely on opioid analgesia alone. His clinical condition remains the same 2 years later.

Discussion

Coeliac plexus block is an established method of pain relief suitable for a variety of causes of intractable abdominal pain, including pancreatitis.[2] CT scanning has been described as a useful adjunct to the technique and enables precise placement of the injecting needle without penetrating nearby structures, such as the kidney and adrenal gland, and also assists the operator to avoid nearby major vessels.[1] The experienced operator uses a combination of CT guidance and a loss of resistance, when the appropriate plane is reached, in order to guide the needle into the region of the coeliac plexus. On the occasions reported the operator was unable to detect a loss of resistance when the needle was advanced and it was not possible to inject

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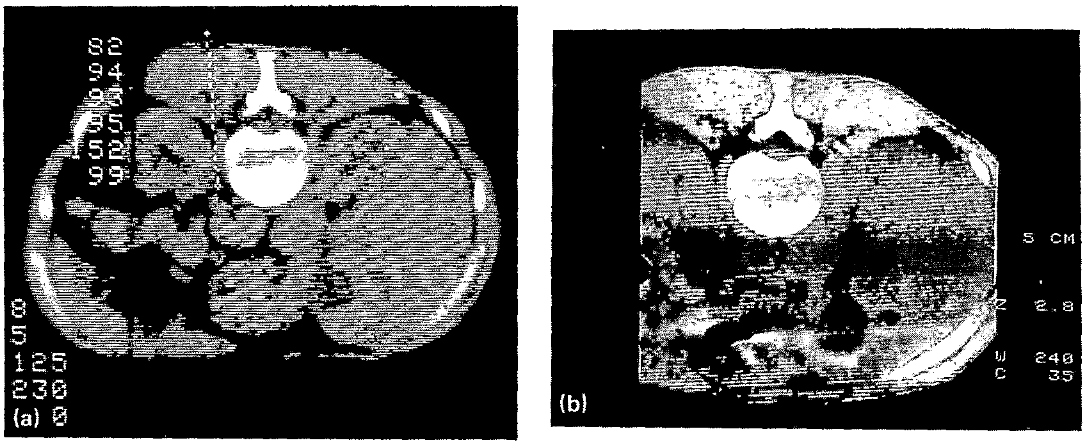

Fig. 1. (a) A CT section through the abdomen at the L_1 level shows the approximate route of the needle for a left-sided coeliac axis block. The needle track terminates in a readily visible fat plane to the left of the aorta. (b) A CT section at the same level, when an attempted left-sided block was unsuccessful, shows obliteration of this plane by dense soft tissue.

contrast through the needle when it was sited in the approximate position of the coeliac ganglion. The CT scans showed soft tissue obliterating the retroperitoneal space to the left, and subsequently to the right of the aorta. We suggest that this represents dense, fibrous tissue induced by repeated injections of alcohol. A similar appearance may be seen with retroperitoneal malignancy, but since the patient remains clinically stable 2 years later, malignancy is unlikely.

The case illustrates that the technique of repeated coeliac plexus block for chronic conditions may be limited by the development of fibrotic tissue in the region of the coeliac plexus. It indicates a further role for CT guidance to establish the presence of such a complication and to direct the injection site to a more favourable area.

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Anaesthesia, 1990, Volume 45, pages 311–313

CASE REPORT

Neuroleptic malignant syndrome in the intensive therapy unit

J. N. MONTGOMERY AND J. W. IRONSIDE

Summary

A case of the neuroleptic malignant syndrome occurred in a 40-year-old male after administration of chlorpromazine while on an Intensive Therapy Unit. Treatment with dantrolene sodium was successful, and a muscle biopsy was examined in the recovery phase of the illness. The importance of this condition and the difficulties in establishing a diagnosis at an early stage in patients on an Intensive Therapy Unit are discussed, along with implications for treatment.

Key words

Muscle, skeletal; pathology, neuroleptic malignant syndrome.
Ataractics; phenothiazines, chlorpromazine.

The neuroleptic malignant syndrome (NMS) is a rare but occasionally lethal response to major tranquillisers.[1] Most of the references to this syndrome are to be found in the psychiatric literature.[2-5] We present a case which highlights the problems and importance of this diagnosis in a patient who had been admitted to an Intensive Therapy Unit (ITU).

Case history

A 40-year-old man was admitted to casualty after a domestic argument which resulted in a penetrating injury to the left side of the chest. The patient was fully conscious and complained of severe pain in the chest for which pethidine 100 mg and prochlorperazine 12.5 mg were given intramuscularly. He was transferred to the operating theatre where anaesthesia was induced with thiopentone 250 mg and suxamethonium 100 mg intravenously. Anaesthesia was maintained with 50% nitrous oxide in oxygen with enflurane and increments of fentanyl.

Exploration through a left thoractomy revealed a large tear in the diaphragm, with abdominal viscera in the chest. Perforations of the stomach were sutured and an exploratory laparotomy carried out through the laceration in the diaphragm. Splenectomy was performed, the abdominal contents replaced and the tear in the diaphragm sutured. He was transferred to ITU for elective overnight ventilation.

His condition was stable on admission to the unit. His therapy included sedation with infusions of midazolam and alfentanil, antibiotic therapy (instituted because of soiling of the pleural cavity with gastric contents) and chlorpromazine suppositories to avoid delirium tremens (a history of heavy alcohol intake had been obtained). His condition gave cause for concern over the next 8 hours; he became hypotensive, and developed a tachycardia and pyrexia (Fig. 1). He was sedated more heavily, neuromuscular blockers were administered, tepid sponging was instituted and rectal paracetamol given. The next morning he was noted to have marked muscle rigidity, muscle fasciculations and opisthotonus. His core temperature had reached 41°C and his abdomen was rigid and silent. He underwent repeat laparotomy, but no further intra-abdominal pathology was found.

He continued to be pyrexial with bouts of tachycardia and hypertension over the next 24 hours despite sedation, ventilation and administration of antibiotics. The rigidity of neck, limbs and abdomen continued. Blood cultures were negative. It was postulated 36 hours after admission that he was suffering from the neuroleptic malignant syndrome; the probable triggers were either chlorpromazine or prochlorperazine. All drugs were stopped except for a papaveretum infusion for analgesia, and ranitidine.

Treatment with dantrolene sodium was instituted after a literature search and consultation with the manufacturers (Norwich Eaton). At this time the patient's temperature

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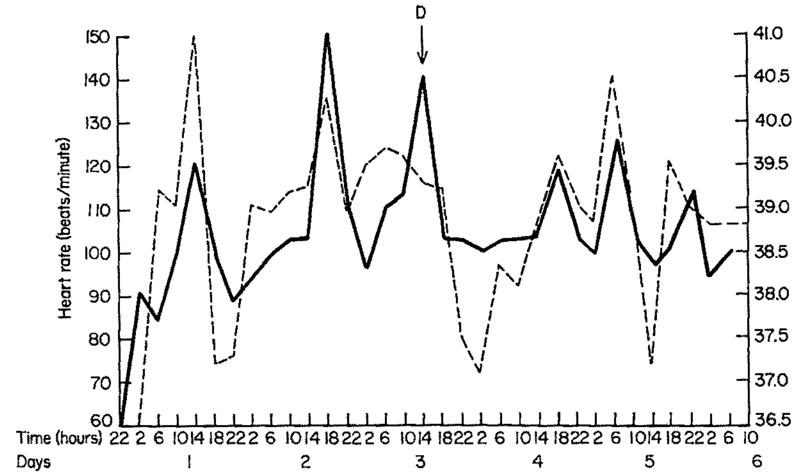

Fig. 1. Temperature and heart rate recordings while in the Intensive Therapy Unit. ——, heart rate; – – –, temperature; D, first dose of intravenous dantrolene.

was 39.5°C, heart rate 140 beats/minute (sinus tachycardia), and blood pressure 170/110 mmHg. The muscular rigidity improved after an intravenous bolus of dantrolene sodium 1 mg/kg. The temperature decreased to 37°C, heart rate to 110 beats/minute, blood pressure to 100/70 mmHg and there was a diuresis of 250 ml/hour. Two further doses of dantrolene were administered intravenously 24 and 36 hours later in response to pyrexia, tachycardia and muscle rigidity.

Antibiotic therapy was reinstituted the next day, as a result of the pyrexia and the presence of purulent sputum. Sputum culture produced no growth but pus cells were present on microscopy. Bowel sounds were heard, and dantrolene 100 mg and bromocriptine 5 mg were given orally as prophylaxis twice and three times a day respectively. The patient made an uneventful recovery; dantrolene and bromocriptine therapy was stopped on his 10th day in hospital after a muscle biopsy had been taken. The patient then discharged himself against medical advice and did not attend for follow-up.

Other investigations carried out were for urinary myoglobins which were negative at the time of the muscle spasms. Serum creatine kinase reached 3500 units/litre before the first dose of dantrolene and decreased to a level of 1700 units/litre 48 hours later.

Muscle biopsy

Cryostat sections of a quadriceps muscle biopsy showed segmental necrosis of muscle fibres. This was most conspicuous in longitudinal sections, and the appearances in a paraffin-embedded sample suggested hypercontraction at the sites of necrosis. A few pale 'ghost' fibres, some of which contained phagocytic cells, were scattered throughout the biopsy (Fig. 2). A mild degree of endomysial oedema was present, but there was no evidence of inflammation or a vascular abnormality. The muscle fibres showed a normal fibre type distribution and normal size in relation to the patient's age and sex (mean diameters: Type I fibres, 70 μm, Type II fibres, 74 μm). Stains for glycogen, lipid and myophosphorylase were normal. No evidence of mitochondrial aggregation or any other underlying cytoarchitectural abnormality was noted.

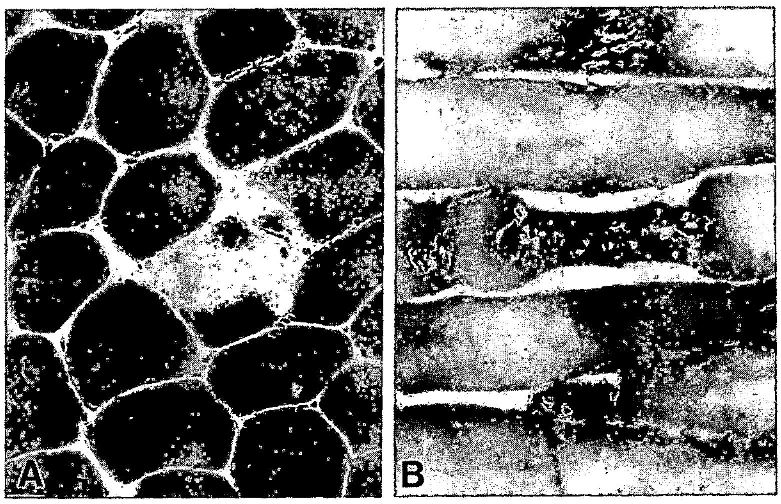

Fig. 2. Skeletal muscle histology. (A) A necrotic fibre is present in the centre of the field (haematoxylin and eosin, x288). (B) Areas of segmental hypercontraction stain darkly on longitudinal section (phosphotungstic acid haematoxylin, x304).

Discussion

The neuroleptic malignant syndrome was described first in 1968 by Delay and Deniker,[1] and is characterised by hyperpyrexia, autonomic disturbances and hypertonicity of the skeletal muscles. It is precipitated most commonly by drug therapy with major tranquillisers, particularly haloperidol. A recent review[5] found that it occurs in 0.5–1% of those taking neuroleptic drugs, and predominantly in young men. It has occurred also after the withdrawal of levodopa in Parkinson's disease[6] and after the administration of non-neuroleptic drugs,[7] e.g. metoclopramide.[8] Major tranquillisers have antidopaminergic activity and are prescribed commonly; their ability to precipitate NMS parallels this antidopaminergic activity.[9] The pathogenesis of NMS is believed to be related to dopamine receptor blockade in the basal ganglia and hypothalamus.[10]

The onset of the syndrome is not related to the duration of therapy or toxic overdose but may be triggered by several factors in susceptible patients; these factors include exhaustion, dehydration and organic brain disease.[9,11,12] The syndrome develops over 24–72 hours. Physical signs include fever, tremors, rigidity, tachycardia, altered level of consciousness, tachypnoea, diaphoresis, hypo- and hypertension, dysarthria and sialorrhoea.[2-4] Laboratory findings include leucocytosis, altered serum transaminases and myoglobinuria.[4,13] Differential diagnosis includes sepsis, tetanus, encephalitis, Parkinson's disease, lethal catatonia, heat stroke, central cholinergic syndrome, drug interactions with monoamine oxidase inhibitors and malignant hyperpyrexia.[2-5] Approximately one third of patients may require admission to the ITU with respiratory failure, renal failure, seizures or cardiac arrest.[2-4,7] The mortality is 20–30%, and is increased if depot forms of the drugs have been used.[7]

Treatment includes supportive therapy (cooling, hydration, diuretics) and low-dose heparin to decrease the risk of venous thrombosis and embolism.[2,7,13] Drug therapy must be aimed at altering the balance between acetylcholinergic and dopaminergic systems in the basal ganglia and hypothalamus. Dopamine agonists[2,7] (levodopa, bromocriptine and amantadine) can only be given orally. Unfortunately, an inotropic infusion of dopamine does not cross the blood–brain barrier because of its low lipid solubility. Anticholinergics such as atropine, hyoscine and benztropine can be used as second-line therapy.[1]

The peripheral manifestations of the syndrome can be decreased by administering dantrolene sodium[14] which is a muscle relaxant by virtue of its blockage of calcium release from the sarcoplasmic reticulum in muscle. This decreases metabolism in muscle and thus reduces the pyrexia and tachycardia. Competitive muscle relaxants may also aid in the treatment by relaxing striated muscle and decreasing metabolism. In contrast to malignant hyperpyrexia, the abnormality in NMS is probably not in the muscle fibres themselves[1,2] and thus relaxants which act at the level of the neuromuscular junction are effective.

The findings in the muscle biopsy are similar to the few previously reported cases of muscle pathology in this disorder.[13,15] It has been suggested that the hyperpyrexia may be due at least in part to heat production in muscle from the metabolism of glycogen and lipid substrates, and this implies partial uncoupling of metabolic phosphorylation from muscle fibre contraction.[15] The evidence of hypercontraction and necrosis in the muscle biopsy from our patient is consistent with this suggestion, but no evidence of lipid or glycogen depletion in the muscle fibres was noted. However, the latter may be a reflection of successful therapeutic intervention, unlike a recently reported case which included postmortem muscle histology.[15] The hypercontraction and rigidity in this disorder may occur as a consequence of uncontrolled calcium release in muscle fibres, and this is the rationale for use of dantrolene sodium.[14]

The syndrome has a wide variety of differential diagnoses in the ITU. Sepsis is the most important; pyrexia, cardiovascular instability and abdominal rigidity suggested in our patient that further intra-abdominal pathology might be present. Leucocytosis in NMS may also suggest sepsis. The early stages of NMS may go unrecognised,[3] and with the increasing use of drugs such as droperidol for anti-emesis in the peri-operative period, NMS should be included in the differential diagnosis of severe postoperative pyrexia. Use of competitive muscle relaxants as an aid to ventilation in the ITU may mask the characteristic rigidity of the syndrome and obscure the diagnosis.

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Anaesthesia, 1990, Volume 45, pages 314–317

APPARATUS

A low flow open circle system for anaesthesia

Part I: Laboratory evaluation at normal and high frequencies

M. K. CHAKRABARTI, R. G. W. STACEY, A. HOLDCROFT AND J. G. WHITWAM

Summary

A circle breathing system was connected by deadspace tubing to an open system valveless ventilator. The minimum volume of this tubing, required to prevent dilution of anaesthetic gas in the breathing system by the driving gas of the ventilator, was determined at frequencies of 15, 30, 60, 100 and 150 breaths/minute, with tidal volumes that ranged from 100 to 1100 ml and a fresh gas supply to the circle system of 1, 2 and 4 litres/minute. At 15 breaths/minute, tidal volumes equal to or less than the deadspace volume could be used safely without any mixing with the ventilator driving gas, when a fresh gas flow of 2 litres/minute or above is supplied to the circle system. At 1 litre/minute of fresh gas flow, mixing occurred at tidal volumes less than the deadspace volume. Mixing of gas occurred in the system at frequencies greater than 30 breaths/minute even when the tidal volume was much less than the deadspace volume. However, at high frequencies of ventilation, since the tidal volume requirement decreases, deadspace tubing with a safe internal volume, that is greater than 600 ml, may be used up to 100 breaths/minute.

Key words

Equipment; closed systems, ventilators.

Low flow anaesthesia using a circle system reduces operating theatre contamination and the cost of anaesthetic drugs. Mechanical ventilation with soda lime absorption in this system can be performed using a variety of ventilators. A prototype valveless ventilator[1,2] in which the breathing tube is open to atmosphere at all times was attached to a circle breathing system using the method described by Jeal[3] and Schoonbee and Conway[4] to assess the suitability of an open system low flow anaesthesia system for future clinical use. The ventilators were connected by deadspace tubing to the circle system in both of these laboratory evaluations of the system.

The length of deadspace tubing required to avoid dilution of the anaesthetic gases by the ventilator gas driving the circle system, was determined in one of these studies using a pressure cycled ventilator.[3] Four metres of standard (22-mm internal diameter) corrugated rubber tubing, that is internal deadspace volume of over 2 litres, was recommended. It was considered that this length of tubing may be excessive, and so a preliminary study was designed to measure the minimum volume of deadspace tubing required to prevent dilution of anaesthetic gas in the breathing system at different frequencies, including high frequencies, tidal volumes and fresh gas flows, using the prototype all-purpose valveless ventilator developed in our department.

Method

An Ohmeda Mark VA circle breathing system was attached by disposable tubing of internal volume 300, 600 or 900 ml to a valveless ventilator (Fig. 1), which utilised oxygen as the driving gas. The Y-piece of the circle system was connected to a 4-litre anaesthetic rebreathing bag. Gas from sampling sites S1 (anaesthetic machine fresh gas) and S2 (inspiratory limb gas) was analysed by a Datex Capnomac for concentrations of oxygen and nitrous oxide. The calibration of the analyser was checked repeatedly during the study period with standard, pre-analysed calibrating gas.

The breathing system was flushed for 10 minutes with 100% nitrous oxide at flow rates of 8 litres/minute before measurements were recorded. The inspiratory:expiratory ratio was maintained at 1:2 for each tidal volume studied. Measurements at S1 and S2 were made with all deadspace volumes in sequence, for frequencies of 15, 30 and 60 breaths/minute and with tidal volumes that increased by 100 ml from 200 to 1100 ml at 1, 2 and 4 litres/minute until oxygen dilution occurred in the circuit as detected by an increase in the oxygen concentration at S2. The fresh gas flow was varied in a similar manner at frequencies of 100 and 150 breaths/minute, but the tidal volume studied ranged from 50 ml and was increased by 10-ml increments

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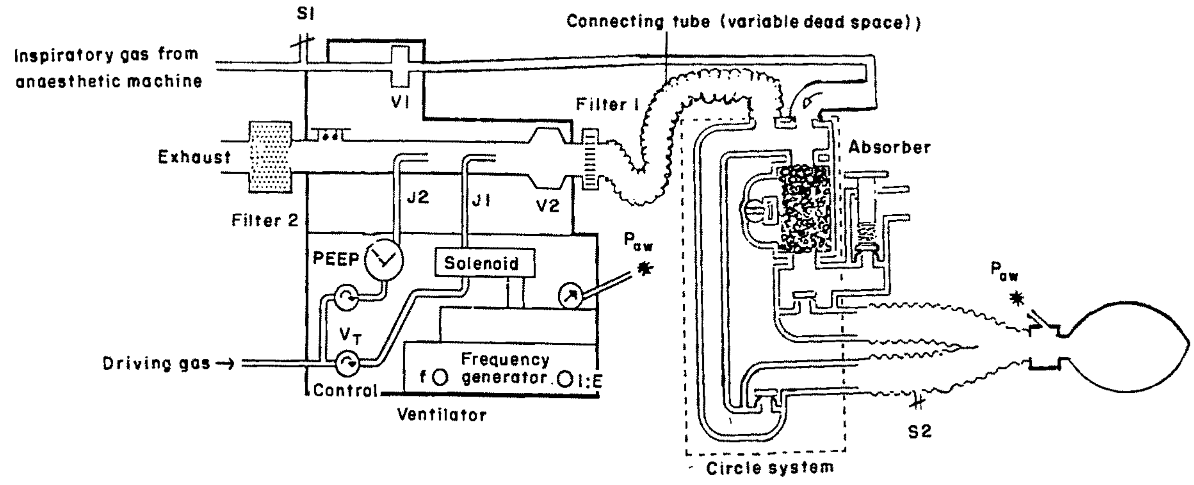

Fig. 1. A diagram of the circle system with fresh gas from the anaesthetic machine entering the system after carbon dioxide absorption. This passes during inspiration unidirectionally along the inspiratory limb to a rebreathing bag and is then exhausted through connecting tubing of variable deadspace volume, attached to a bacterial filter (Filter 1) and out of the system past two driving jets (J1: inspiratory; J2; PEEP) and a noise filter (Filter 2). The driving gas of the ventilator maintains intermittent positive pressure through J1 and positive end expiratory pressure through J2. The tidal volume measured by the ventilator is detected by volume sensors at V1 and V2. The inspiratory:expiratory (1:E) ratio control can be preset, and the airway pressure (P_{aw}) measured. Sampling sites to measure gas concentrations were located at S1 (anaesthetic machine fresh gas flow) and S2 (inspiratory limb).

until mixing occurred. Gas concentrations (at S1 and S2) were measured at least 10 minutes after any adjustment, in frequency, tidal volume or flow rate. The system was flushed with 100% nitrous oxide at 8 litres/minute for 10 minutes when it was contaminated with oxygen at S2, so that gas concentrations measured at S1 and S2 were the same.

The expired tidal volumes were measured in this prototype valveless ventilator using two flow sensors (Magtrack, Ferraris Medical Ltd), one of which measures the total expired volume, including the fresh gas volume during the expiratory phase, and the other the fresh gas volume for the expiratory time taken from the jet pulse generator. The difference between these volumes is determined electronically and displayed on the ventilator as the tidal volume.[5] The deadspace tubing internal volume was determined by the water displacement physical method and measured in a graduated cylinder.

Results

The results for each of the deadspace volumes are presented in Table 1. With a normal frequency of 15 breaths/minute and 4 litres/minute fresh gas flow, the tidal volume at which dilution occurred was greater than the connecting tube deadspace volume, that is above 400, 800 and 1100 ml respectively. Mixing occurred at lower tidal volumes at this same frequency when the fresh gas flow was reduced to 2 litres/minute. With 300- and 600-ml tubings these tidal volumes were similar to the deadspace volume but with the 900-ml tubing, the tidal volume for mixing was 20% below the deadspace volume. However, when only one litre/

Table 1. The minimum tidal volume (litres) before dilution of the inspired gas occurred at fresh gas flow rates of, 4, 2 and 1 litres per minute with 15, 30, 60, 100 or 150 breaths per minute and connecting deadspaces of 300, 600 or 900 ml.

Frequency (breaths per minute)	Minimal tidal volume (litres) before dilution Fresh gas flow rates (litres/minutes)		
	4	2	1
300 ml deadspace			
15	0.4	0.4	0.3
30	0.4	0.3	0.17
60	0.2	0.15	0.12
100	0.2	0.1	0.1
150	0.1	0.07	0.05
600 ml deadspace			
15	0.8	0.6	0.4
30	0.6	0.4	0.2
60	0.4	0.2	0.1
100	0.2	0.1	0.1
150	0.2	0.1	0.08
900 ml deadspace			
15	1.1	0.7	0.6
30	0.7	0.5	0.3
60	0.4	0.3	0.2
100	0.2	0.2	0.1
150	0.2	0.1	0.07

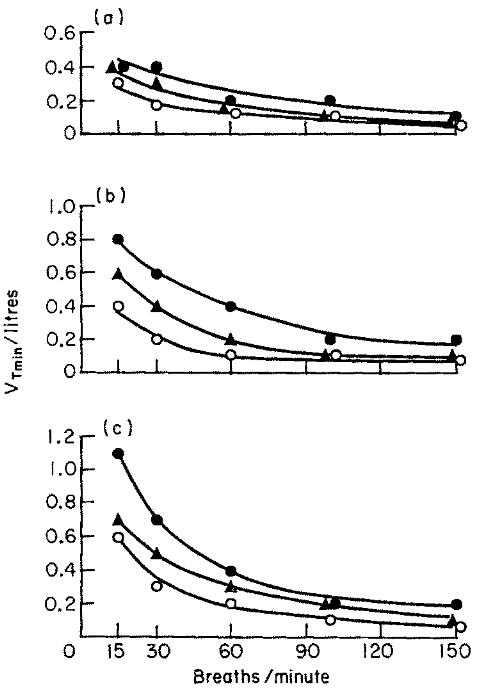

Fig. 2. The minimum tidal volume (V_{Tmin}) before dilution of inspired gas occurred at increasing frequencies of ventilation and fresh gas flow rates of 4, 2, and 1 litres/minute in an open circle system, with deadspace tubing of (a) 300, (b) 600, or (c) 900 ml that connected the ventilator with the breathing system. ●, 4 litres/minute; ▲, 2 litres/minute; ○, 1 litre/minute.

minute of fresh gas was supplied to the circle system, mixing always occurred at tidal volumes less than the deadspace volume.

As the frequency was increased to 30 breaths/minute, the tidal volume at which dilution occurred was above 300 ml for the 300-ml deadspace tubing, but above 65 and 55% of the deadspace volumes with 600- and 900-ml tubings respectively when the fresh gas flow was 2 litres/minute.

Mixing always occurred in the system at tidal volumes less than the deadspace volumes, as the frequency was increased to more than 30 breaths/minute. The maximum tidal volumes that could be used without mixing were observed to follow an exponential pattern (Fig. 2a, b and c).

When dilution of the fresh gas by the driving gas occurred it happened rapidly, within one minute, at all frequencies of ventilation. The amount of dilution on different occasions was measured for up to one hour and no further change occurred in this dilution. It was also observed that at 15 breaths/minute, although mixing occurred at the tidal volume equal to the deadspace values at the lowest fresh gas flow (1 litre/minute), the mixing never exceeded 10%.

Discussion

This study shows that the mixing of ventilator driving gas through a wide-bore connecting tube, with anaesthetic gas fresh flow in the circle system, depends on four variables. These are tidal volume, internal deadspace of the connecting tube, anaesthetic fresh gas flow rate and ventilation frequency (Fig. 2).

When the tidal volume was increased, mixing of the gas (oxygen) driving the ventilator was only observed as the tidal volumes exceeded the connecting deadspace volumes of 300 and 600 ml at 30 and 15 breaths/minute respectively, provided the fresh gas flow was 2 litres/minute; for the 900-ml deadspace tubing, mixing occurred below the deadspace volume even at 15 breaths/minute with the same fresh gas flow (Table 1). However, at 4 litres/minute fresh gas flow, the tidal volumes may exceed the deadspace volume before mixing occurs at 15 breaths/minute.

The ventilator driving gas works as a pneumatic piston to drive the anaesthetic gas to the patient. The contribution of fresh gas towards the tidal volume becomes progressively less within the circle system and mixing becomes inevitable, when the anaesthetic gas flow is decreased. This was clearly demonstrated by reducing the anaesthetic fresh gas flow from 4 to 1 litres/minute.

A possible cause of mixing of the ventilator driving gas with the anaesthetic gas at large tidal volumes less than the connecting deadspace volume, and at small tidal volumes during high frequency ventilation, is the increase in inspiratory flow which is common to both these situations. The flow will increase if tidal volumes are increased for the same inspiratory-to-expiratory ratio and frequency of ventilation, or when the ventilatory rate is increased so that the inspiratory time shortens. It can be postulated that with an increase in inspiratory flow, the wave front of the ventilator gas will penetrate further into the anaesthetic gas collected in the connecting deadspace tubing at the end of expiration.

The inspiratory-to-expiratory ratio was 1:2 in this study, so the mean inspiratory flows can be calculated. It was observed in general that when the mean inspiratory flow exceeds 30 litres/minute mixing occurs irrespective of the tidal volume or frequency of ventilation with a fresh gas flow of 2 litres/minute.

It was concluded in a similar study[3] that the minute ventilation has very little effect on mixing when the rate of ventilation was increased from 10 to 20 breaths/minute at constant tidal volumes. However, the rate of ventilation was increased by shortening the expiratory time, but the inspiratory time remained the same.

Under these conditions the inspiratory flow will not change. In another study,[4] which did not include the carbon dioxide absorber in the circle system, Schoonbee and Conway observed an increase in mixing with an increase in the frequency of ventilation, which is similar to our own findings.

Turbulence in the tubing may also occur and this will enhance the mixing, and will depend on the diameter and surface of the tubing. No variations in the diameter of the tubing were made in this study because large bore (22-mm ID) tubings are standard for adult clinical use.

This laboratory evaluation of an open system circle pneumatically driven by a valveless ventilator through 22-mm internal diameter connecting tubing confirms that at low fresh gas flows of 2 litres/minute or above and at normal respiratory frequencies and tidal volumes, mixing of the gases will not occur provided that the deadspace volume of the connecting tubing is equal to or exceeds the tidal volume.

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APPARATUS

A low flow open circle system for anaesthesia

Part 2: Clinical evaluation

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Summary

A prototype valveless ventilator was attached by open deadspace tubing to a circle system and used to ventilate the lungs of 12 patients with low flows of anaesthetic gases for periods between 60 and 120 minutes during intra-abdominal surgery. Anaesthesia was induced with thiopentone and maintained with nitrous oxide 50% in oxygen and enflurane. This was reduced to 2 litres/minute after a 10-minute period of nitrogen wash out and stabilisation of anaesthetic gas concentration, with an initial anaesthetic gas flow of 6 litres/minute. The concentration of oxygen, carbon dioxide, nitrous oxide and enflurane were measured in the outflow from both the anaesthetic machine and the inspiratory limb of the circle system. The measured mean inspired oxygen and nitrous oxide concentrations showed no significant variation throughout the low flow period of the study. This new low flow open circle ventilation system appears to offer some advantages in terms of safety and versatility over other systems which are discussed.

Key words

Equipment; anaesthesia systems, ventilators.

Low flow anaesthesia, with rebreathing of anaesthetic gases after absorption of carbon dioxide by soda lime in a circle system, is used to reduce the fresh anaesthetic gas supply and hence cost and potential pollution. The circle system can be used during spontaneous and positive pressure ventilation,[1,2] when the reservoir bag can be either compressed mechanically or pneumatically, or replaced by a bellows or rolling diaphragm, using a spillover valve or auxiliary system to exhaust gas from the breathing system during expiration.[3] Alternatively, a ventilator can be attached to the circle system[4,5] so that gas from the ventilator acts as a pneumatic piston to drive anaesthetic gases supplied to the circle system into the patient. The ventilator gas, either air or oxygen, does not pass into the circle system, provided the volume of deadspace connecting tubing is adequate.[6] Excess gas is vented from the system through the ventilator exhaust port.

A ventilator has been developed without any valves in the breathing duct, which is continually open to the atmosphere.[7,8] This study was designed to assess the suitability of such an open system for low flow anaesthesia using a circle system.

Methods

Equipment

The ventilator was attached by standard disposable breathing tube (22 mm internal diameter, 76 cm long and internal volume of 650 ml as measured by water displacement) to a circle absorber (Ohmeda Mark 5A) in which the inspiratory limb and the connexion to the tracheal tube were fitted with sampling ports (Fig. 1). The circle system was checked for leaks by maintaining a pressure of 3 kPa for 15 minutes in the system. Oxygen was supplied to the driving jet of the ventilator. Anaesthetic gas was delivered to the circle system from an Ohmeda Excel 410 machine in a conventional manner. The fresh anaesthetic gas flow and expired tidal volume were measured by volume sensors in the ventilator as described previously.[9] The tidal volume was maintained at less than the volume of deadspace tubing. The ventilator frequency was 15 breaths/minute and the I:E ratio 1:2. Airway pressure, driving gas pressure and respiratory fresh gas flow were measured every 15 minutes.

Gas concentrations were measured at 15-minute intervals

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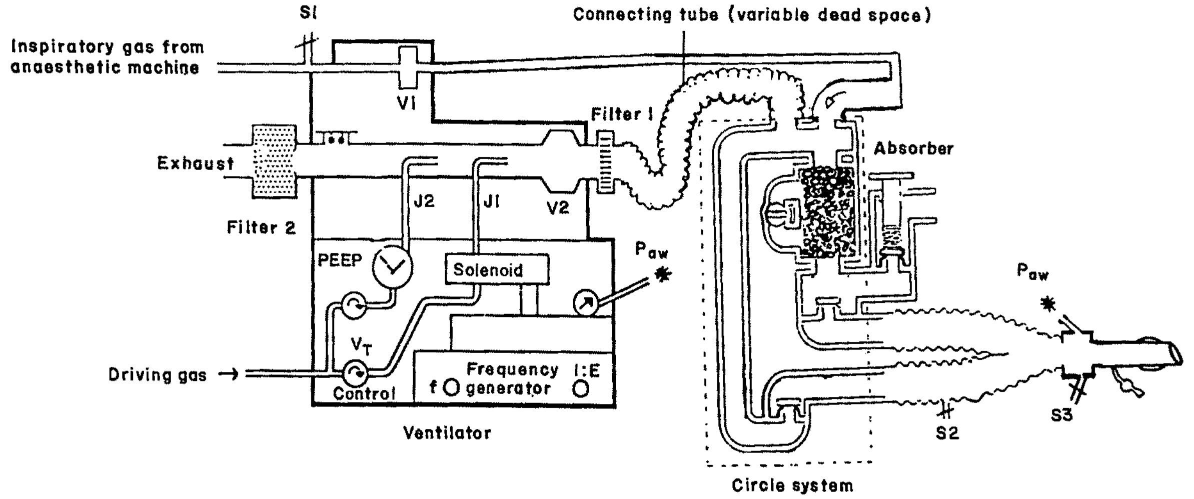

Fig. 1. A diagram of the breathing system and ventilator. The inspiratory anaesthetic gas mixture from an anaesthetic machine flows through a flow sensor (V1) into the fresh gas inlet of a conventional circle breathing system (Ohmeda Series 5A) with soda lime absorption for removal of expired carbon dioxide. The inspired gas is delivered to the patient via the inspiratory limb of the circle system during the inspiratory phase. The exhaled gas, during the expiratory phase, flows through the expiratory limb of the circle system to the CO_2 absorber then through the deadspace tubing, a bacterial filter (Filter 1), and jet manifold to the atmosphere via a second filter (Filter 2) to act as a silencer, to a scavenging system. In the circle system during the next inspiration, gas, which has collected in the deadspace connecting tubing and fresh gas flowing continuously from the anaesthetic machine, is driven to the patient by the jet (J1). J1 is the ventilator-driving jet whose driving pressure controls the tidal volume by working as a pneumatic piston. J2 was not used in this study but can provide positive end-expiratory pressure. The ventilating frequency and I:E ratio are controlled by an electronic pulse generator driving a solenoid valve connected to J1. The expired tidal volume is measured by the use of two electronic respirometers, one of which measures the total expired volume (V2) and the other the fresh gas volume (V1) for the expiratory time taken from the jet pulse generator. The difference between these volumes is obtained electronically and is displayed as the tidal volume with an accuracy of greater than 6%. S1 and S2 are the gas sampling ports for the analysis of O_2, N_2O, CO_2 and enflurane at the anaesthetic machine outlet and the inspiratory limb respectively. The airway pressure and end-tidal enflurane and CO_2 (S3) are measured at the junction of the breathing system and tracheal tube.

at three points: the outflow from the anaesthetic machine (S1), the inspiratory limb of the circle system (S2) and the tracheal tube connector (S3) by connecting a multigas and vapour analyser accurate to 2%[10] (Capnomac Datex). Site S3 was used to measure end-tidal carbon dioxide and enflurane concentration. The gas analyser was calibrated with the Datex 'Quick Cal' Capnomac calibration canister and the calibration was checked repeatedly during the study.

Anaesthetic procedure

Local ethics committee approval and informed consent was obtained from 12 women scheduled for lower abdominal surgery. Their mean age was 39 years (SD 17) and weight 64 kg (SD 8). Anaesthesia was induced, after premedication with an oral benzodiazepine, with thiopentone 3 mg/kg and their tracheas intubated after neuromuscular blockade with vecuronium 0.1 mg/kg; further doses of vecuronium were given as indicated by train-of-four stimulation. Anaesthesia was maintained with 50% nitrous oxide in oxygen and enflurane.

Initially, a Manley ventilator was used for intermittent positive pressure ventilation of the lungs. The ventilator was adjusted to maintain an end-tidal CO_2 concentration of between 3.9 and 4.3%. Oxygen saturation and the electrocardiogram were continuously monitored and the arterial blood pressure was measured at 3-minute intervals.

The circle breathing system driven by the prototype ventilator was connected to the tracheal tube, when the patient was ready for surgery and her vital parameters stable. The minute volume of the anaesthetic respiratory fresh gas from the anaesthetic machine was supplied to the circle system initially with the same flow (approx 100 ml/kg) in order to flush the system. The tidal volume was adjusted to maintain the end-tidal CO_2 within the normal range specified and the concentration of enflurane at the vaporizer was adjusted to the level required in the inspired limb (S2) to maintain anaesthesia with cardiovascular stability. The anaesthetic gas flow rate was reduced to 2 litres/minute (O_2 1 litre and N_2O 1 litre) after 10 minutes. Thereafter no further adjustments were made to the anaesthetic machine. Between patients, the soda lime was renewed.

Statistical analysis

The data obtained were analysed by two-way analysis of variance and a p value of < 0.05 was considered to be significant.

Results

Oxygen concentration (Table 1)

There was no significant difference in oxygen concentration between the anaesthetic gas mixture supplied from the anaesthetic machine and the inspiratory gas delivered to the patient from the circle system when the anaesthetic gas flow was 2 litres/minute. The mean oxygen concentration delivered by the anaesthetic machine varied between 49.3 and 52.0% as measured at S1, and the mean inspired concentration measured at S2 varied between 48.8 and 51.0%. The mean oxygen saturation in the patients was 98% or above throughout.

Table 1. Effect of time on gas concentrations, peak airway pressure (PAP) and expired tidal volume (V_T) during low flow anesthesia in patients who have abdominal surgery, using an open circle system with intermittent positive pressure ventilation. Low flow anaesthesia started at 0 minutes. Sampling sites S1 and S2 record anaesthetic gas concentration from the anaesthetic machine and inspiratory limb respectively. Site S3 was used for the measurement of end-tidal concentration of enflurane and of carbon dioxide. All 12 patients completed the first hour of study, and surgery continued for a further hour in a few of the patients. There was no significant difference in any of the parameters with time (statistical two-way analysis of variance). Values: mean (SD).

Time (minutes)		15	30	45	60	75	90	105	120
n		12	12	12	12	6	4	1	1
O_2%	S1	49.7 (1.9)	49.3 (1.8)	49.8 (2.1)	49.5 (1.9)	50.6 (1.1)	50.0 (1.4)	52.0	52.0
	S2	50.3 (4.5)	48.8 (4.9)	49.0 (4.7)	49.7 (8.6)	50.8 (6.1)	49.8 (5.3)	51.0	50.0
N_2O%	S1	51.4 (2.0)	51.5 (1.5)	51.3 (1.8)	51.4 (2.1)	50.0 (0.0)	50.8 (1.0)	50.0	52.0
	S2	51.4 (4.6)	51.9 (6.1)	52.8 (5.2)	49.9 (10.0)	48.5 (6.2)	51.3 (5.5)	52.0	53.0
End tidal CO_2%	S3	3.9 (0.4)	4.0 (0.5)	4.0 (0.5)	4.1 (0.5)	4.3 (0.4)	4.1 (0.4)	3.8	4.1
Enflurane %	S1	1.5 (0.5)	1.4 (0.6)	1.3 (0.7)	2.1 (0.9)	1.4 (1.0)	1.4 (0.8)	2.3	0.7
	S2	0.7 (0.2)	0.8 (0.2)	0.7 (0.3)	0.7 (0.3)	0.7 (0.2)	0.5 (0.3)	1.3	0.4
	S3	0.5 (0.1)	0.6 (0.1)	0.6 (0.2)	0.5 (0.3)	0.6 (0.2)	0.6 (0.1)	0.9	0.4
Sao_2%		98.5 (0.8)	98.2 (1.7)	98.4 (1.2)	98.5 (0.9)	98.6 (0.5)	98.0 (1.0)	98.0	99.0
V_T (ml)		497 (71)	469 (48)	470 (44)	458 (55)	472 (42)	468.0 (53)	510.0	545.0
PAP kPa		1.1 (3.4)	1.1 (3.0)	1.1 (2.8)	1.2 (2.7)	1.2 (3.2)	1.1 (1.2)	10.0	10.0

Nitrous oxide concentration

The mean nitrous oxide concentration supplied at 1 litre/minute from the anaesthetic machine (S1, Table 1) varied between 50 and 52%, and in the inspiratory limb from 48.5 to 53.0% (S2, Table 1), but there was no statistically significant difference between these values throughout the study period.

Enflurane concentration

The concentration of enflurane vapour in the gas supplied from the anaesthetic machine was always higher than the inspired concentration in the circle system (Table 1) and varied according to clinical requirements to maintain stable heart rate and blood pressures.

Ventilation

Adequate ventilation of the patients' lungs was achieved throughout the study as shown by the end-tidal CO_2 concentration which was maintained within a narrow range (Table 1). The tidal volume was relatively constant and no significant differences observed. The ventilator driving gas pressure requirement was nearly constant with a mean of 100 kPa (SD 15). The mean peak airway pressure was 1.1 to 1.2 kPa throughout the study.

Discussion

The breathing system used in this study was open to atmosphere at all times since there is no expiratory valve in the ventilator. Anaesthetic vapour delivered by the machine in the fresh gas flow would have to be increased, and the oxygen concentration would not have been maintained if there was a significant leak in the system. The valves in the circle system are passive and activated by the inspiratory and expiratory gas flows rather than by a mechanical system. This may certainly be a safety feature of this open circuit circle system, since there cannot be a build-up of pressure, such as may occur with an excess respiratory gas flow, or malfunctions of valves; thus the fresh gas flow does not require adjustment throughout the anaesthetic. A breathing system open to the atmosphere also allows spontaneous ventilation without increasing the resistance against which the patient expires. In addition a change from positive pressure ventilation to spontaneous ventilation can readily be made when the neuromuscular blockade is reversed for recovery at the end of surgery.

Another safety aspect which requires consideration is the use of oxygen as the driving gas. Ventilation will proceed with oxygen in the event of a failure of anaesthetic fresh gas flow, and because of the CO_2 absorber in the circle system there should be no rebreathing.

Jeal[4] describes the use of a pressure generator ventilator in a similar breathing system. The valveless ventilator described in this study operates as a true pressure generator in an open system so that the airways pressure will never exceed the preset airways pressure. The airways pressure and, hence, the tidal volume, in the case of the former system, will vary with changes in the fresh gas flow; for example with an I:E ratio of 1:2 one third of the respiratory fresh gas is added to the tidal volume. Therefore, at the start of anaesthesia, when the system needs to be flushed with high gas flows, the tidal volume of the ventilator will have to be set much lower than the required volume, and then will need to be increased when flow rates of fresh gas are instituted, otherwise hypoventilation occurs.

It is also difficult to measure expired tidal volume in such systems. With a Wright respirometer it is not possible with continuously flowing respiratory fresh gas to measure the expired tidal volume at the expiratory port, and positioning it at the mouth can increase the apparatus deadspace. However, the valveless ventilator used in this study does not impose any such problems and the tidal volume is independent of anaesthetic fresh gas flow. Moreover, it is fitted with flow sensors away from the mouth which derive the tidal volume from the difference between the anaesthetic fresh gas flow during expiration and the total expiratory flow.[9] Measurement of the end-tidal CO_2 in this study confirmed the adequacy and constancy of measured tidal volumes and also allowed between-patient comparison of other gases, for meaningful results.

Inspired gas monitoring is essential in a low flow circle system.[5] However, it should be borne in mind that a loss of 200–400 ml of gas will be expected by continuous use of a gas-sampling type of analyser and should be accounted for, especially in a closed system for safe low flow anaesthesia, unless the sampling gas is returned to the system. The oxygen concentration measured in the inspired limb was found to be stable and reflected a mixture of expired gas (with carbon dioxide removed) and fresh gas flow. Even when the soda lime is changed regularly unless it is monitored an increase in carbon dioxide tension may occur. A multiple gas analyser as used here will provide suitable monitoring. It is recommended that the best position for monitoring anaesthetic gases is in the inspiratory limb, except for the end-tidal concentration of carbon dioxide, and although the measurement of oxygen is mandatory, carbon dioxide and anaesthetic vapour concentration will also contribute to safe anaesthesia.

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Anaesthesia, 1990, Volume 45, pages 322–326

Forum

Propofol sedation after open heart surgery
A clinical and pharmacokinetic study

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Summary

One hundred adult patients who required mechanical ventilation after open heart surgery for coronary revascularisation were studied. All received a standard premedication and a high dose opioid anaesthetic. On arrival in the intensive care unit they were allocated randomly to receive either propofol or midazolam to maintain sedation within a predetermined range. Patients who received propofol underwent extubation of the trachea, using standard criteria, after a mean time (log-transformed) of 7.6 minutes after sedation for approximately 17 hours. The corresponding time was 125 minutes in those given midazolam. There were significantly higher morphine requirements during sedation, and higher arterial carbon dioxide tensions 30 minutes after extubation of the trachea, in patients who received midazolam. Pharmacokinetic analysis in 20 patients showed that the elimination half-life of propofol was prolonged (470 minutes) and clearance was reduced (1.14 litres/minute) compared with subjects who had not undergone cardiopulmonary bypass. The rapid clinical recovery was reflected in a rapid redistribution half-life (13.4 minutes), but this was also longer than the redistribution time of 2–4 minutes in other patients.

Key words

Anaesthetics, intravenous; propofol.
Hypnotics; midazolam.

Propofol (2,6-di-isopropylphenol) is an alkyl-phenol which is now used extensively both as an induction agent and for maintenance of anaesthesia during short operative procedures. Studies have indicated a virtual lack of cumulation after incremental administration[1] with rapid, clear-headed recovery when the drug is administered as a continuous infusion for maintenance of anaesthesia in procedures lasting over 2 hours.[2] We have performed a clinical and pharmacokinetic trial to investigate the use of propofol by infusion for sedation in patients who required mechanical ventilation after surgery for coronary revascularisation under nonpulsatile cardiopulmonary bypass with moderate hypothermia.

Patients and methods

Ethics committee approval was sought and granted before the start of this study. A clinical trial exemption certificate was obtained because propofol was not licensed for infusion in the postoperative period. One hundred adult patients who required mechanical ventilation after open heart surgery for coronary revascularisation were studied. Patients with hepatic dysfunction (noted on routine biochemical screening), receiving concurrent benzodiazepine therapy or with a history of hypersensitivity to either propofol or benzodiazepines were excluded. All patients received the same barbiturate, opioid, glyceryl trinitrate premedication. Anaesthesia was induced with fentanyl 50 μg/kg, and maintained with air/oxygen supplemented, if necessary, with halothane. No benzodiazepine or propofol was administered during the operative procedure. Neuromuscular blockade was produced with pancuronium 0.1 mg/kg.

Artificial ventilation was continued at the end of the procedure and the patient was transferred to the intensive care unit (ICU). Neuromuscular blockade was not reversed. On arrival in ICU the patients were allocated randomly to receive either propofol or midazolam for sedation. Analgesia was provided in both groups by intermittent intravenous bolus doses of morphine sulphate 2.0 mg as required.

The level of sedation was assessed using the criteria described by Ramsay *et al.*[3] These are: 1, patient anxious and/or agitated; 2, patient cooperative, orientated, and tranquil; 3, patient responds to commands; 4, asleep but with brisk response to light glabellar tap or loud auditory stimulus; 5, asleep, sluggish response to light glabellar tap or loud auditory stimulus; 6, asleep, no response.

Sedation was started when the patients opened their eyes and moved all four limbs to command. The aim in this study was to maintain sedation at level 3, at which it was possible to enquire about, and treat, any discomfort. Propofol was administered via the internal jugular vein as a 1% solution by a motorised syringe pump (Graseby MS 2000). Sedation was initiated with a bolus of 50 mg in combination with an initial infusion of 50 mg/hour. Thereafter the infusion rate (limits 10–250 mg/hour) was adjusted by the nursing staff to maintain the target sedation

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Table 1. Physical characteristics and duration of cardiopulmonary bypass (CPB). Data are expressed as mean (SEM).

Group	Age (years)	Gender	Weight (kg)	Duration of CPB (minutes)
Propofol ($n=50$)	58.6 (1.1)	43 M	71.9 (1.4)	93.6 (3.4)
Midazolam ($n=50$)	57.8 (1.4)	45 M	68.5 (1.4)	95.2 (3.5)

level. Midazolam was given intravenously in bolus doses of 2.0 mg intermittently when required.

Ventilation was with oxygen-enriched air, and the ventilator settings were adjusted to maintain the arterial oxygen tension between 15 and 25 kPa and the arterial carbon dioxide tension between 4.0 and 4.5 kPa. Weaning from the ventilator was achieved using standard criteria[4] (tidal volume > 5 ml/kg, vital capacity > 10 ml/kg and respiratory rate > 10 but < 30 breaths/minute). Arterial blood gases were measured 30 minutes after extubation. Records were kept of the time from arrival in ICU to the start of sedation, the duration of sedation and time to extubation.

Systemic and pulmonary arterial pressures, central venous pressure and heart rate were measured continuously and maintained within predetermined values. Records were kept of blood loss and administration of blood and other fluids; the aim was to maintain the haematocrit between 30 and 35%. Inotropic support was not required in any patient.

Ten patients in each sedation group were selected at random to participate in a pharmacokinetic study. Samples of arterial blood (5 ml) were taken before administration of the sedative drug and at 7.5, 15, 30, 60, 120 minutes and 4, 8 and 12 hours after the initial dose. A sample was taken immediately before a supplementary dose, in the midazolam group, to reflect trough concentrations. Another sample was taken just before the end of the propofol infusion or the last bolus dose of midazolam at approximately 0600 hours the next morning. Further samples were obtained at 15, 30, 60, 120 minutes and 4, 8, 12, and 24 hours after discontinuation of sedation. In the propofol group the samples were stored at 4°C and analysed within 24 hours for total blood propofol concentration using gas-liquid chromatography.[5] In the midazolam group the samples were kept at 4°C and centrifuged within 24 hours; the plasma was stored at −20°C until analysed for total plasma midazolam concentration using gas-liquid chromatography.[6] The coefficients of variation of the methods of analysis were 7.5% (midazolam) and 4.5% (propofol) over the range of concentrations obtained in this study. Pharmacokinetic analysis of data obtained after the end of administration of sedation was performed using a noncompartmental method for estimation of clearance, volume of distribution and area under the curve.

A nonlinear least squares regression analysis, with a weighting factor of $1/c^2$, was used for estimation of distribution and elimination half-lives

Nominal data were analysed using the Chi-square test. Other data were analysed using the unpaired t-test or analysis of variance. Times to extubation of the trachea demonstrated a skewed distribution, and the data were log-transformed before analysis.

Results

Fifty patients were included in each sedation group, and there were no significant differences between the two groups with regard to age, weight, gender, or cardiopulmonary bypass time (Table 1). Table 2 shows the doses of sedative and analgesic drugs used. Patients sedated with midazolam had a significantly greater requirement for morphine ($p < 0.001$). Patients who received propofol were sedated satisfactorily (levels 2–5) for 86% of the time compared with 56% in those who received midazolam ($p < 0.001$). The level of sedation was controlled more easily and more rapidly with propofol (Fig. 1).

Table 2. Mean (SEM) requirements of sedative agents, morphine and glyceryl trinitrate.

	Propofol	Midazolam	p
µg/kg/minute	19.2 (1.2)	0.56 (0.03)	
mg/hour	82.8 (4.7)	2.3 (0.11)	
Morphine			
mg/kg	0.57 (0.03)	0.72 (0.04)	<0.001
µg/kg/minute	0.55 (0.03)	0.75 (0.03)	<0.001
Glyceryl trinitrate			
µg/kg/minute	1.57 (0.08)	1.82 (0.12)	ns

ns, not significant.

There were no significant differences between the two groups in the times from arrival in ICU to the start of sedation: the mean (SEM) time was 99.7 (5.4) minutes in the propofol group and 103.8 (7.1) minutes in the midazolam group. The sedative drugs were administered for approximately 17 hours. The mean time (log transformed)

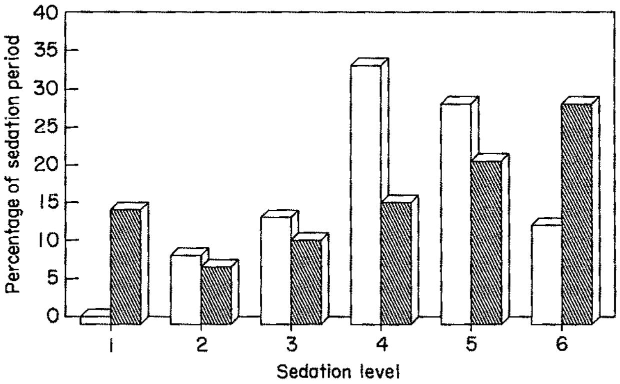
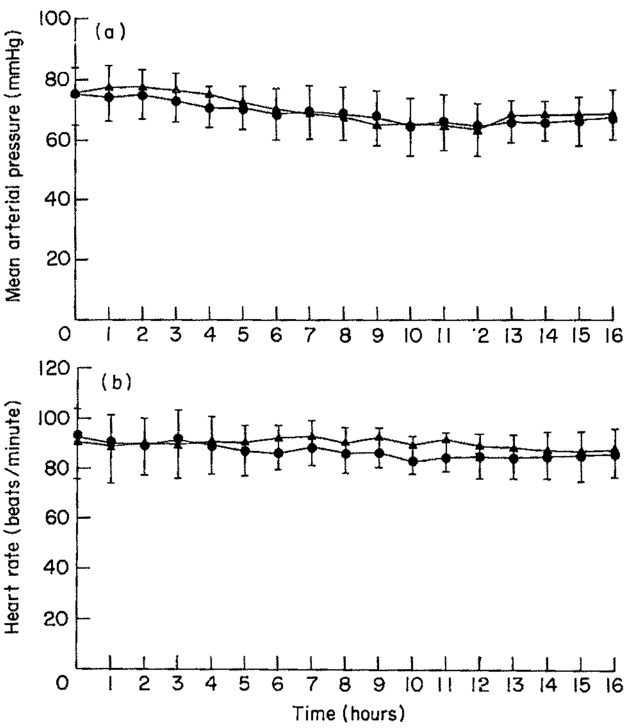


Fig. 1. Percentage of time at each sedation level. Target level 3; acceptable levels 2–5. □, propofol; ▨, midazolam.



Figs. 2a, b. Changes in mean arterial pressure and heart rate during sedation. —●—, propofol; —▲—, midazolam.

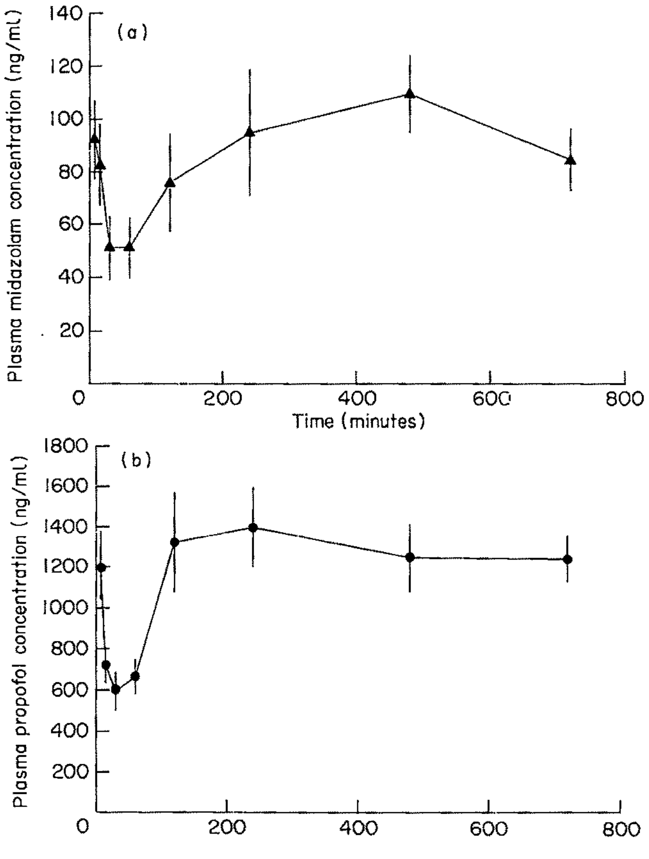


Fig. 3a, b. Drug plasma concentration. Time profiles during administration of midazolam (a) and propofol (b). Bars represent SD.

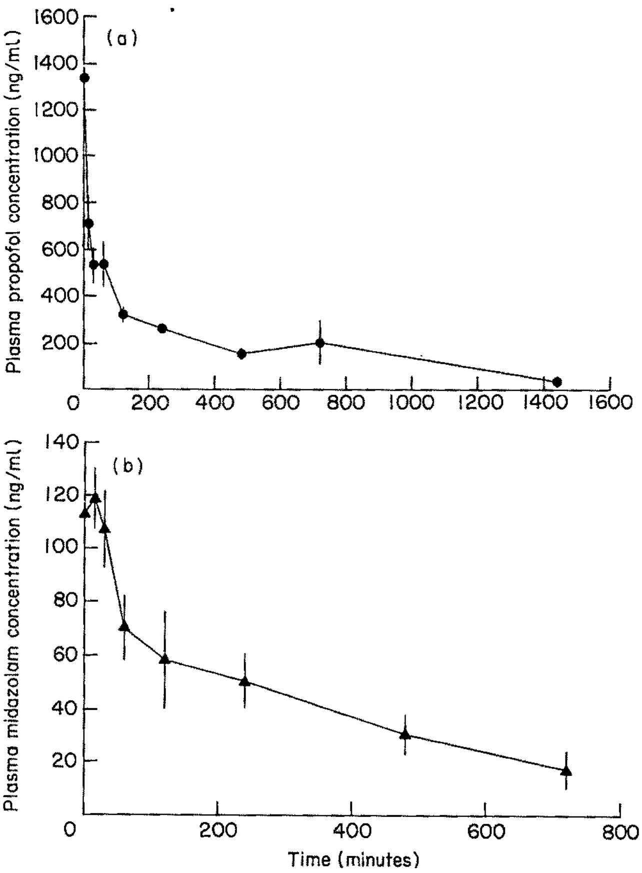


Fig. 4a, b. Decay in plasma concentrations of propofol (a) and midazolam (b) with time. Bars represent SD.

from discontinuation of sedation to extubation was 7.6 minutes (95% confidence intervals 2.9–19.1) in the propofol group compared with 125 minutes (73.6–208.5) in patients who received midazolam. Arterial carbon dioxide tension 30 minutes after extubation was significantly higher in patients sedated with midazolam (Table 3).

All patients were haemodynamically stable throughout the duration of the study. Figure 2 shows changes in mean arterial pressure and heart rate from the start of sedation until the decision was taken to stop treatment. There were no significant differences between the groups; mean arterial pressure after 9–12 hours was significantly lower than awake values ($p < 0.01$) in both groups. This was of no clinical significance since the patients were warm, well perfused and producing more than 0.5 ml/kg/hour of urine.

Table 3. Recovery characteristics. Data are expressed as mean (SEM).

	Propofol	Midazolam	p
Sedation time (hours)	16.7 (0.4)	16.2 (0.3)	ns
Time to extubation (minutes)	11.9 (2.5)	127.9 (9.9)	<0.001
$Pa\text{co}_2$ (kPa)	5.6 (0.1)	6.4 (0.1)	<0.001

ns, not significant.

The two groups of patients in whom the pharmacokinetic study was performed were comparable in respect of age, weight, gender, height and cardiopulmonary bypass time (Table 4). Figure 3a shows the decay in plasma midazolam concentration after a bolus dose of 2 mg and the trough plasma concentrations associated with intermittent administration; these indicate that there was a delay of 4–6 hours before steady state was achieved. The use of a bolus and infusion technique with propofol was associated with a more rapid achievement and maintenance of steady state (Fig. 3b).

Plasma propofol concentrations decreased rapidly when administration was stopped (Fig. 4a); the redistribution half-life was 13.4 (2.8) minutes. Midazolam concentrations decreased more slowly, (Fig. 4b) with a redistribution half-life of 30.1 (2.6) minutes. The elimination half-life of propofol was 470 minutes and clearance was 1.14 litres/minute (Table 5). Computer analysis of the data demonstrated that elimination of propofol best fitted an open two-compartmental model.

Table 4. Physical characteristics and duration of cardiopulmonary bypass (CPB) in patients in whom pharmacokinetics were studied. Data are expressed as mean (SEM).

Group	Age (years)	Gender	Weight (kg)	Height (cm)	Duration of CPB (minutes)
Propofol ($n = 10$)	59.4 (2.9)	8 M	69.9 (3.5)	170.8 (2.4)	88.8 (5.5)
Midazolam ($n = 10$)	56.0 (2.7)	8 M	72.5 (3.1)	170.5 (2.8)	95.9 (5.0)

Table 5. Pharmacokinetic variables. Data are expressed as mean (SEM).

	Propofol	Midazolam
Weight (kg)	69.9 (3.5)	72.5 (3.1)
Clearance (litres/minute)	1.14 (0.16)	0.37 (0.05)
Elimination half-life (minute)	470.2 (60.5)	403.6 (73.3)
Redistribution half-life (minutes)	13.4 (2.8)	30.1 (2.6)

Discussion

Patients require ventilatory support for a variable period of time after open heart surgery for which high dose opioid anaesthesia is used. Such patients usually require sedative drugs to facilitate ventilation and it had been our practice to use a benzodiazepine/opioid combination. We preferred the drug midazolam to other benzodiazepines because of its superior pharmacokinetic properties.[7] However, research in our own unit[8] demonstrated that midazolam clearance may be prolonged excessively in some patients after cardiopulmonary bypass. In 1987 Grounds *et al.*[9] published a preliminary report on the use of propofol infusion for sedation after cardiac surgery. They demonstrated that propofol was suitable when infused for 8 hours (on average) in that the infusion was associated with easily controlled sedation, cardiovascular stability and rapid recovery. However, the study can be criticised because the high-dose opioid anaesthetic technique employed for the surgery might still have exerted a significant effect after 8 hours.

In our unit, we employ mechanical ventilation overnight for logistical reasons and therefore had the opportunity to assess propofol infused over a more prolonged period of time and to compare it with our standard regimen of intermittent midazolam. Infusion requirements for propofol were 82.8 mg/hour compared with 54.8 mg/hour in Grounds' study.[9] Midazolam requirements were also higher in our study (2.3 mg/hour compared with 1.1 mg/hour). These differences probably reflect the high doses of opioid used in Grounds' study.

Our aim was to maintain a sedation level of 3 (using Ramsay's criteria) and in this we failed. However, it was easier to control the level of sedation in the propofol group; the satisfactory range was achieved for 86% of the time compared with 56% in the midazolam group. Like Grounds *et al.*,[9] we found that patients who received propofol had significantly lower analgesic requirements and this reflected our improved ability to communicate with the patients. It has been our practice to measure blood gases 30 minutes after extubation of the trachea. Sedation with midazolam was associated with a significantly higher $P\text{aco}_2$, indicating a significant degree of alveolar hypoventilation. These patients were less able to cooperate with the physiotherapists after extubation.

Steady-state plasma concentrations were achieved more rapidly in the propofol group. The redistribution and elimination half-lives, and clearance, of propofol were prolonged when compared with subjects who did not undergo cardiopulmonary bypass and moderate hypothermia.[10,11] It is of interest to note that the elimination of propofol was longer than that of midazolam.

Plasma concentrations of propofol declined more rapidly after the end of sedation than those of midazolam; the redistribution half-lives were 13.4 and 30.1 minutes respectively. This more rapid redistribution is possibly reflected in the superior clinical recovery characteristics of propofol.

In conclusion, propofol provided effective sedation with haemodynamic stability in patients after cardiac surgery. The sedation was controlled easily and associated with very rapid recovery. The redistribution, elimination and clearance of the drug is prolonged, probably as a consequence of cardiopulmonary bypass with moderate hypothermia.

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Electro-acupuncture and postoperative emesis

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Summary

One hundred unpremedicated female patients of ASA grade 1 or 2 who underwent laparoscopy as outpatients were allocated randomly to one of four groups. All patients received general anaesthesia with fentanyl, thiopentone, halothane, nitrous oxide and oxygen; suxamethonium was given to facilitate tracheal intubation. In the recovery room, group 1 (control) received no treatment; group 2 received electro-acupuncture at the P6 point (Neiguan) on the right side for 15 minutes, group 3 received transcutaneous electrical nerve stimulation at the P6 point on the right side for 15 minutes and group 4 received prochlorperazine 5 mg intravenously. Any act of vomiting, including dry retching, during the first 3 postoperative hours was regarded as postoperative emesis. The incidence of postoperative emesis was 11/25 (44%) in group 1, 3/25 (12%, $p < 0.05$) in group 2, 9/25 (36%) in group 3, and 3/25 (12%, $p < 0.05$) in group 4. Our results suggest that electro-acupuncture is as effective as prochlorperazine, and may be better than transcutaneous electrical nerve stimulation, in reducing postoperative emesis.

Key words

Vomiting; incidence, antiemetics.
Acupuncture.

Nausea and vomiting are among the most frequently encountered forms of morbidity in the postoperative period and during cancer chemotherapy. Many drugs are effective in the management of nausea and vomiting, but none is completely devoid of side effects. Traditional Chinese acupuncture is claimed to be useful in the management of nausea and vomiting. Needling at the P6 (Neiguan) acupuncture point was shown recently to be effective in the prevention of nausea and vomiting in well-designed studies, either postoperatively or during cancer chemotherapy, if needling is performed whilst the patient is awake.[1-4] In contrast, one investigation found no antiemetic effect of acupuncture with needling performed under general anaesthesia.[5] We undertook the present study to corroborate these findings.

Methods

One hundred unpremedicated female patients of ASA grade 1 or 2, aged between 18 and 50 years and 42–79 kg in weight, who underwent outpatient laparoscopy, were selected for the study. The protocol was approved by the Human Research Committee of Chang Gung Memorial Hospital, and all patients gave verbal consent to participate in the study. All patients received general anaesthesia which was induced with fentanyl 2 μg/kg and thiopentone 5 mg/kg; tracheal intubation was performed after administration of suxamethonium 1–1.5 mg/kg. Anaesthesia was maintained with halothane and nitrous oxide 50% in oxygen. All patients awoke in the operating room at the end of the procedure. The patients were allocated randomly to one of four groups, each consisting of 25 persons, immediately after admission to the recovery room. Patients in group 1 received no treatment. Those in group 2 received electro-acupuncture (EAP) at the P6 acupuncture point (Neiguan) of the right forearm for 15 minutes. The P6 point was located between the tendons of palmaris longus and flexor carpi radialis muscles, 3–5 cm proximal to the distal wrist crease; it was verified by insertion of a 2.54 cm 32-gauge stainless steel needle until the feeling of numbness and tightness (teh-chi) was obtained. Electrical current was then applied to the needle from a pulse generator (Itorater E4A type, Ito Co., Tokyo, Japan) at 3 Hz. A bidirectional pulse wave was used with a pulse width of 0.75 msec and the output voltage was increased to a degree just less than that which caused discomfort. Patients in group 3 received transcutaneous electrical nerve stimulation (TENS) for 15 minutes with two ECG electrodes, one placed in the right antecubital fossa and the other at the right P6 point, using the same pulse generator as in group 2 but at 30 Hz; the output voltage was adjusted as in group 2. Patients in group 4 received prochlorperazine 5 mg intravenously. No opioid drugs were administered during the 3-hour study period. Any act of vomiting, including dry retching, which occurred during the first 3 postoperative hours was regarded as postoperative emesis; no enquiry was made about the presence or absence of nausea. The significance of differences between the control and other groups was analysed by the Chi-square test with Yates' correction.

Results

The age, weight, and duration of anaesthesia did not differ significantly among the groups (Table 1). The incidence of postoperative emesis was significantly lower in patients treated with EAP (3/25 compared with 11/25; $p < 0.05$) or

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Table 1. Mean (SD) age, weight and duration of anaesthesia, and incidence of postoperative emesis, in the first 3 postoperative hours.

	Age (years)	Weight (kg)	Duration (minutes)	Incidence of emesis
Group 1 (control)	30 (6)	52 (7)	54 (16)	11/25 (44%)
Group 2 (EAP)	32 (5)	53 (8)	47 (10)	3/25 (12%)*
Group 3 (TENS)	32 (6)	48 (4)	56 (17)	9/25 (36%)
Group 4 (prochlorperazine 5 mg)	30 (6)	52 (7)	49 (9)	3/25 (12%)*

EAP eletro-acupuncture, 3 Hz, at right P6 point for 15 minutes; TENS, transcutaneous electrical nerve stimulation, 30 Hz, at right P6 point for 15 minutes

*$p < 0.05$ compared with group 1.

prochlorperazine (3/25 compared with 11/25; $p < 0.05$) than in those who received no treatment. There was no signifcant difference between the control and TENS groups (11/25 compared with 9/25). The difference between the EAP and TENS groups was not statistically significant. Patients complained frequently of a feeling of tiredness and sleepiness during EAP treatment; these sensations usually persisted for some time after EAP had ceased. No such sensations were reported by any of the patients who received prochlorperazine or TENS.

Discussion

Nausea is a subjective sensation. Its incidence may be influenced by many factors, including a period of fasting. Over 50% of female subjects in one survey experienced nausea after an average period of fasting of 7 hours.[6] Our patients did not fast for equal periods, and thus we omitted nausea as a variable in the present study.

The results of our investigation showed that EAP is as effective as prochlorperazine 5 mg intravenously, and appeared to be better, although not significantly, than TENS in the prevention of postoperative emesis. Nausea and vomiting result from stimulation of the chemoreceptor trigger zone and/or emetic centre in the medulla oblongata.[7] The ability of prochlorperazine, a dopamine antagonist, to relieve emesis relates probably to the high density of dopamine (D_2) receptors in the area postrema, which contains the chemoreceptor trigger zone.[8]

Most studies of acupuncture are about its analgesic effects. Several lines of evidence suggest that acupuncture analgesia may be mediated by endogenous opioid peptides.[9,10] Both manual acupuncture and EAP analgesia may be blocked by the opioid antagonist naloxone. The prolonged time course of analgesia, which persists after the acupoint stimulation has ceased, suggests the release of humoral factors. This has been supported by studies in which transfer of cerebrospinal fluid (CSF) from animals treated with acupuncture into the cerebral ventricle of other animals produced analgesia in the recipient animals. Central mechanisms are implicated because the analgesia is blocked by procaine infiltration of acupuncture points, or if peripheral nerves that supply the acupoint are anaesthetised. There have been some direct measurements of endogenous opioid peptides during acupuncture. Clement-Jones *et al.*[11] reported that β-endorphin-like immunoreactivity in CSF increased during low-frequency EAP, whereas met-enkephalin concentrations did not change. In contrast, met-enkephalin levels, but not β-endorphin, in CSF increased significantly after high-frequency EAP.[12] Reversal of acupuncture analgesia by naloxone was almost complete in 2 Hz EAP, partial in 80 Hz EAP, and weak after direct cutaneous electrical stimulation; this confirms that the most imporant role of endorphins is in low-frequency EAP. Thus it seems probable that analgesia produced by low-frequency EAP may involve increases in the CSF concentrations of β-endorphin. β-endorphin has equal preference for μ and δ opioid receptors, whereas enkephalins bind predominantly to δ-receptors only; the relative binding affinities of μ- and δ-receptors for naloxone are 85% and 6% respectively.[13]

Costello and Borison[14] showed that opioids have emetic as well as antiemetic effects; the antiemetic effects were blocked by naloxone given systemically, but the emetic effects were blocked only when naloxone was administered directly into the cerebral ventricle. They suggested that the occurrence of vomiting when naloxone was given after the administration of morphine resulted from antagonism of the antiemetic action of morphine at the vomiting centre, but not of its emetic action at the chemoreceptor trigger zone. Naloxone administered into the cerebral ventricle may evoke vomiting that is not affected by ablation of the chemoreceptor trigger zone. Costello and Borison speculated that this phenomenon may result from a normal antiemetic tone provided by an endogenous morphine-like factor. Harris hypothesised that different types of opioid receptor are associated with emesis; one (μ-receptor, which is effectively blocked by naloxone) mediates antiemetic effects and another (δ-receptor, which is less well blocked by naloxone) mediates an emetic effect.[15] The antiemetic effect of low-frequency EAP may be mediated by the release into the CSF of the endogenous opioid β-endorphin which potentiates the endogenous antiemetic tone. However, other mechanisms may be involved also.

Appropriate P6 (Neiguan) acupuncture point stimulation, either manual or electrical, is effective in the prevention of postoperative and chemotherapy-induced emesis, if performed in awake patients.[1-4] It is not known if acupuncture during anaesthesia is effective in man; there have been conflicting reports.[16,17] Weightman found that manual needling at the P6 acupuncture point during isoflurane anaesthesia resulted in no beneficial antiemetic effect.[5] In order to produce analgesia, acupuncture requires intact transmission from periphery to central nervous system. However, general anaesthetic agents may reduce transmitter release in spinal cord neurones, with the result that excitatory synaptic transmission is blocked preferentially at low concentrations and inhibitory transmission is at least unaffected, if not enhanced.[18,19]

The important role of 5-hydroxytryptamine (5-HT) in acupuncture analgesia has been established.[10] Two distinct central 5-HT pathways seem to be activated by acupuncture; from the raphe nuclei of the lower pons and medulla, one spreads downward to the dorsal horn of the spinal cord, where incoming pain signals are inhibited, and another spreads upward and releases 5-HT in forebrain structures. Stimulation of the raphe nuclei may also cause almost natural sleep.[20] This may explain why the patients given EAP experienced tiredness. Brattberg[21] reported that 56% of 122 consecutive patients treated with acupuncture for pain sustained drowsiness in an unpredictable manner.[21]

Application of acupuncture is cumbersome and time-consuming and many of its characteristics are unknown, e.g. the most suitable frequency, intensity and interval of electrical stimulation, and the duration of clinical effects. However, exploration for the antiemetic mechanism of acupuncture may assist in our understanding of the neural pathways and receptor specificities of the vomiting reflex.

Acknowledgment

We thank our gynaecological and anaesthetic colleagues in the Chang Gung Memorial Hospital for their cooperation in the study.

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The effect of diclofenac and nefopam on postoperative dental pain

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Summary

Eighty-two outpatients who received general anaesthesia for surgical removal of maxillary or mandibular third molars were given either diclofenac 75 mg or nefopam 20 mg intramuscularly for postoperative pain control. They and the control group were also allowed oral paracetamol as required. The results showed that there was no significant pain relief from these single intramuscular injections.

Key words

Pain; postoperative.
Analgesics; diclofenac, nefopam.

Accepted 5 October 1989.

Many drugs have been used in an effort to control pain after day-case dental surgery. The use of opioids is inappropriate because of the high incidence of unwanted side effects such as drowsiness, dizziness, nausea and vomiting. Oral analgesics given after general anaesthesia may be ineffective or at best provide analgesia only after a considerable delay because of inability to take the medication, vomiting and protracted drug absorption. The nonsteroidal anti-inflammatory drug (NSAID) diclofenac sodium, when administered orally, was useful in the control of pain after surgical removal of third molars.[1] Diclofenac is now available as an intramuscular preparation and the aim of this study was to compare the analgesic effect of parenteral diclofenac with nefopam, a cyclized analogue of diphenhydramine, chemically unrelated to the opioid analgesics and which may be given parenterally. Both diclofenac and nefopam were given in a controlled, randomised double-blind study of patients after surgical removal of third molars under general anaesthesia.

Methods

Hospital ethics committee approval was obtained to study 82 healthy outpatients between the ages of 18 and 55 years who presented for surgical extraction of maxillary or mandibular third molars. The patients were screened for fitness for anaesthesia and gave written informed consent. Those who were pregnant, had a history of peptic disease, intolerance to NSAIDs or were currently taking NSAIDs were excluded.

The patients were randomly allocated to receive either intramuscular diclofenac 75 mg, nefopam 20 mg or to a control group. The injections were given after induction of anaesthesia; it was therefore not thought necessary to give the control group a placebo intramuscular injection.

No premedication was given. Anaesthesia was induced with methohexitone 1–1.5 mg/kg. Nasotracheal intubation was facilitated with suxamethonium 1–1.5 mg/kg and the patients were allowed to breathe spontaneously a mixture of halothane in nitrous oxide and oxygen through a Lack coaxial system.

Bone removal, when necessary, was achieved with water-cooled burrs or chiselling. Antibiotics, if given, were either penicillin V or metronidazole in standard doses. All operations were completed within 45 minutes.

A verbal pain score was obtained between 30 and 60 minutes after recovery from anaesthesia. The patients were asked to describe their pain as none, mild, moderate or severe. The patients were allowed home within 2–4 hours, with 20 paracetamol tablets 500 mg, and accompanied by a responsible adult. They were given a questionnaire to complete during the next 24 hours and asked to return it in a prepaid envelope provided. The questionnaire asked them to assess the pain they experienced during the 24 hours after surgery using the same grades as in the initial postoperative pain score. They were also asked to note the number and time of ingestion of paracetamol tablets, including those taken in hospital before discharge, and to note any pain at their injection sites or the presence of any nausea or vomiting.

Analysis of variance was carried out by the Statistical Package for Social Sciences using the University of Manchester computer.

Results

Sixty-six (80.4%) of the questionnaires were returned correctly completed and only these have been included in the analysis.

There was a preponderance of females within each group, but no significant differences with regard to sex, age or weight (Table 1).

Table 1. Patient details. Values are expressed as mean (SD).

	Males	Females	Age (years)	Weight (kg)
Diclofenac	6	17	27.6 (9.7)	63 (10)
Nefopam	5	17	25.8 (9.7)	64.8 (11.9)
Control	7	14	23.3 (8.9)	60.8 (13.5)

Table 2. Mean pain scores. The verbal responses were scored as none, 0; mild, 1; moderate, 2; severe, 3.

	1 hour pain	24 hour pain
Diclofenac	1.26	1.43
Nefopam	1.1	1.7
Control	1.0	1.38

Table 2 shows that at one hour after recovery from general anaesthesia there were no significant differences in pain intensity. The 24-hour retrospective pain score again showed no difference between groups, but there was a significant increase in pain intensity within each of the groups.

The number of tablets taken before 1500 hours on the day of surgery (all surgery was performed before 12 noon) was recorded in an attempt to identify those patients who developed early pain. There was no significant difference in numbers of tablets taken in the three groups. The number of patients who experienced nausea and vomiting in the 24 hours after surgery was also similar in the three groups (Table 3).

Table 3. The numbner of paracetamol tablets taken before 1600 hours on the day of surgery and the incidence of nausea and vomiting.

	Number of tablets taken before 1600 hours Mean (95% confidence limits)	Patients feeling sick or vomiting (%)
Diclofenac	5.2 (3.6–6.8)	8/23 (35)
Nefopam	6.4 (4.8–7.6)	10/22 (45)
Control	4.6 (2.9–6.3)	7/19 (37)

Discussion

There are a variety of reasons why wisdom teeth are extracted under general anaesthesia as opposed to local analgesia. These include the availability of anaesthetic services, the surgeon's preference and the patient's demand. Fear of dental surgery is a common reason for general anaesthesia and one of the components of this fear is dental pain. The anaesthetist who can offer a smooth, pain-free emergence from anaesthesia and persisting analgesia without the risk of respiratory depression or nausea and vomiting will be able to help the patient in genuine need of general anaesthesia and allay some of the fears in the patient truly terrified of dental treatment.

Narcotic agents are the standard for postoperative pain relief, but these drugs may not be appropriate for use in day-case units since they may cause respiratory depression and nausea. Earlier workers have shown that the nonsteroidal group of drugs may be useful for the management of postoperative dental pain. Matthews *et al.*[1] reported that oral diclofenac given in two doses of 50 mg each was more effective than placebo or paracetamol in the control of pain after dental surgery under local anaesthesia. De V. Joubert[2] and Henrikson[3] have shown similar efficacy for oral diclofenac if taken in more than one dose.

Nefopam has not been widely used in the management of postoperative dental pain, but a recent study showed that administration of regular oral nefopam may be useful.[4]

It was anticipated that by the administration of analgesics intramuscularly early during the course of anaesthesia, consistent pain relief could be obtained. This approach avoids slow and erratic drug assimilation that occurs after oral administration after general anaesthesia.

However, we have been unable to demonstrate that a single intramuscular dose of either diclofenac 75 mg, or nefopam 20 mg, affects dental pain in the first hour after recovery from general anaesthesia, or that any beneficial effect was experienced by the patients during the 24 hours after anaesthesia.

This finding agrees with the results of our previous report in which a single intramuscular dose of nefopam or diclofenac failed to reduce the consumption of morphine given by a patient-controlled analgesic system after major abdominal surgery.[5]

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ANAESTHESIA AND THE LAW

Series of errors which culminated in death

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On 21 January 1989, a man with a long history of complicated haemophilia was admitted to hospital with a severe headache. He was found to have suffered a large intracerebral haemorrhage and was transferred to the University Hospital, Nottingham for surgery. Unfortunately, during an operation of burr hole aspiration of the haematoma, the patient suffered a period of hypoxia and cardiac arrest. The haematoma was evacuated rapidly. Subsequently the patient failed to recover properly and further investigations revealed the presence of severe cortical hypoxia. He then remained in a vegetative state until he died on 30 June 1989.

At the coroner's inquest, the anaesthetist said that he had realised things were not progressing correctly and that 'the trouble was a culmination of a series of small errors'.

These 'small' errors included delay and difficulty in transferring the bed into the operating theatre, delay in connecting the patient to the anaesthetic machine, not checking the machine and failing to notice a lever left on the wrong setting; the blood pressure monitor and carbon dioxide monitor were operating erratically, making it difficult to find a cause for what was happening.

The background facts

Late at night on 22 January 1989, Mr Michael Melbourne, a 56-year-old haemophiliac, with a large right frontal intracerebral haematoma, was admitted to the Department of Neurosurgery at University Hospital, Nottingham. The patient was drowsy and disorientated in time and space, but opened his eyes spontaneously, would utter monosyllabic words and obey commands. His CT scan showed considerably raised intracranial pressure from the haematoma which required immediate relief. The patient had been given full doses of Factor 8 and was considered adequately covered for surgery.

The prognosis was poor and it was decided that a burr hole aspiration of the haematoma should be performed that night; if required, a definitive trephine evacuation of the haematoma could be performed the next day. The situation was explained to the patient's wife who gave her consent to proceed.

At about 2330 hours, Dr M.D. Mitchell, then a registrar in anaesthetics, was alerted. At the inquest he stated that he was not able to see the patient before he was brought to the theatre, but that at about 0015 on 23 January he checked the equipment in the anaesthetic room and the operating theatre. At about 0040, the patient arrived and he was able to make a brief assessment of his condition.

Preparation for emergency neuro-anaesthesia was routine and a 'rapid sequence induction' of anaesthesia with pre-oxygenation was used and the patient given fentanyl 50 μg thiopentone 325 mg and suxamethonium 100 mg intravenously. Intubation was described as 'easy and successful'. (No volatile agent was used at any stage.) At 0100, 35 mg atracurium was administered intravenously. During the preparation for surgery, the Dinamap blood pressure monitor worked erratically. The ECG was normal throughout. Following a satisfactory reading of the blood pressure monitor at about 0110 hours the patient was ready for transfer into theatre. Unfortunately, the anaesthetist was then trapped for 'nearly a minute' while considerable difficulty was experienced in manoeuvring the bed into theatre. During this time, the patient was deprived of oxygen. The anaesthetist was anxious that the patient should receive a supply of oxygen as soon as possible and switched on the gas supply and ventilator and attached the ventilator system as soon as possible.

The surgeon told the coroner, Mr Alan J. Moore, that on initial skin incision there was very little bleeding and the blood appeared to be desaturated. He said he alerted the anaesthetist to this and the anaesthetist immediately checked the ventilation. Asystole occurred at this point but in case this reflected raised intracranial pressure, he rapidly exposed and incised the dura to decompress the haematoma; 30 ml of liquid blood was obtained. By then, normal heart rhythm was re-established and the appearance of the blood returned to normal.

The anaesthetist's account of events was considerably more detailed. He said that it was during the preparation for surgery that the patient began to look unwell with a slightly blotchy, pale, greyish skin, but at that stage the anaesthetist could find no gross abnormalities to explain this change. Unfortunately, the carbon dioxide and blood pressure monitors were not working properly and another monitoring trolley was sent for. In the interim, the anaesthetist switched the gas supply to 100% oxygen and listened to the patient's lungs, where he said he could hear breath sounds in both axillae as before.

As the surgeon began operating, the patient was being connected to the new monitoring trolley. The surgeon remarked *inter alia*, that the blood was dark and that the patient was moving. The anaesthetist gave a second dose of atracurium 15 mg, and changed the ventilator to the auxilliary outlet which supplied a Waters system. He manually ventilated the patient's lungs on the assumption that there had been a rapid rise in intracranial pressure, which was causing the bradycardia, and that reduced cardiac output was becoming apparent. This was about 1 to 2 minutes after the second dose of atracurium.

By now, said the anaesthetist, the patient's condition was worsening rapidly. He became obviously cyanosed and the ECG indicated increased bradycardia. An ODA administered atropine 0.6 mg intravenously while the anaesthetist continued manual ventilation. It was, however, only when the anaesthetist 'visually checked the circuit and ventilator again', that he noticed that the selection lever was in the wrong position ('manual' mode and not 'spirometer-in' mode). He immediately corrected the setting, switched the auxiliary system back to the ventilator and re-attached the ventilator to the patient and commenced external cardiac massage, which was now needed to combat the patient's increasing bradycardia. The operation continued throughout and the ODA administered 1 mg adrenaline intravenously.

About 30 seconds after commencing external cardiac

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massage, the surgeon aspirated blood from the brain. The patient's ECG tracing returned then to a normal sinus rhythm without obvious ischaemia. By 0130 the patient's condition was stable again but over the next 5 minutes he developed hypertension with tachycardia which required treatment. At about 0135 the anaesthetist added nitrous oxide to the gas supply and shortly afterwards he gave 10 mg practolol slowly and then fentanyl 100 μg. The patient's pulse and blood pressure returned to more normal levels. It was decided after consultation to sedate and ventilate the patient overnight.

The next morning an attempt was made to wean the patient from the ventilator. On examination he was found to have some response to painful stimuli with no eye opening and no vocalisation. A further CT scan showed some residual haematoma, although the appearances were much improved. A formal craniotomy and evacuation of the clot were later performed but the patient never recovered consciousness. He died on 30 June 1989.

The coroner recorded a verdict of accidental death.

Comment

The routine adopted for anaesthetising this patient on a bed (rather than a trolley), in another room, then disconnecting him from oxygen and moving him while disconnected to a point where he could be reconnected to an oxygen supply seems clumsy and ill-conceived for a number of obvious reasons, all too graphically illustrated by events. Why a bed and not a trolley? Why a different room? Why was there no continuous procedure possible? How did the anaesthetist allow himself to become 'trapped behind the end of the bed' so that he was unable to proceed to the theatre and connect up the patient? His evidence was that normally this takes only a few seconds but on this occasion it took about a minute. During this time the patient was deprived of oxygen, though he was 'not completely paralysed'.

The anaesthetist's understandable anxiety and eagerness to connect the patient to the oxygen supply was offered as an explanation for his failure to (re-)check the settings on the equipment and to note that the ventilator system was not connected to the fresh gas supply. But surely any checks on equipment should routinely be made *before* and not during procedures? And there appears to have been ample time for this. Dr Mitchell stated that he was alerted at 2330 but it was not until 0015 that he went into the operating theatre, as he says, to check the equipment. That done, he then went to wait for the patient's arrival (25 minutes later at 0040) in a coffee lounge. Unfortunately, the situation seems to have been compounded by the operational failure of the carbon dioxide and blood pressure monitors which the anaesthetist had to have replaced. Apparently, the unsatisfactory condition of the monitors was recorded neither by the last user of the monitors nor noticed by the anaesthetist during his pre-operative checks of the theatre.

The Association of Anaesthetists of Great Britain and Ireland are shortly due to publish a checklist in the hopes that such avoidable errors may be prevented.

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Sir R.R. Macintosh

It was a pleasure to read the obituary of Sir Robert Macintosh who, with Magill, was, without doubt, one of the two outstanding seminal contributors to modern British anaesthesia.

Although I never was fortunate enough to work with him, I had the privilege of meeting him on a number of occasions after his retirement. His former colleagues have, I imagine, considered the principle of a permanent memorial to his name, but may I ask them to consider its orientation towards the practical aspects of anaesthesia, intensive care or pain relief.

There would, I am sure, be a wide response from even those who knew him only through his publications and equipment, especially if there was a limit to the amount of a contribution.

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A Patent application

A Patent application for an anaesthetic machine which is of considerable interest is reported. It was designed and used about the same time as Boyle's first nitrous oxide/oxygen machine and the circumstances of its use give a striking illustration of the state of the art of anaesthesia during World War I. The use of nitrous oxide with oxygen was pioneered by Hewitt but his apparatus never became popular. Several American machines to deliver the two gases were devised between 1910 and 1915; the most important was probably Gwathmey's.

World War I demonstrated that anaesthesia with chloroform or spinal blockade was extremely dangerous in patients with shock or severe sepsis. Anaesthetics were administered by unit medical officers for the first 2 years of the war in the British medical services. Specialist anaesthetists were appointed in 1916 for the first time as additional officers on the staffs of the casualty clearing stations. Their numbers were insufficient to meet the huge demand and, in 1918, 200 specially trained nursing sisters were appointed.[1] The advent of anaesthetists and the arrival in France of the Americans stimulated interest in the use of nitrous oxide/oxygen anaesthesia. Boyle, who had met Gwathmey in America in 1912, renewed their acquaintance in 1917 when both were serving in France. He was then persuaded to try

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Gwathmey's machine and this led to the development of the first Boyle machine.

A Patent application, concerning a 'Device for Administering Anaesthetics' in the Department of Anaesthetics in Edinburgh Royal Infirmary is dated April 1918. Cylinders of nitrous oxide and oxygen, each fitted with a pressure gauge and a reducing valve, were connected to two gasometers and a mixing device. The gasometers ensured that the pressures were equalised, and the mixing valve allowed variable concentrations of oxygen/nitrous oxide as well as the admission of air to the patient. The diagram in the patent application is shown in Figure 1.

This machine was designed and used, not by a doctor, but by a Chaplain to the Forces, the late Canon John Allan Gray, CF, MC. He apparently succeeded in doing a short course in anaesthetics and was allowed to administer anaesthetics in emergency operations in the front line while, at the same time, carrying out his priestly ministrations. However, he found that many men died during surgery and devised his own machine which he used regularly with considerable success. Canon Gray's brother, Frank, an engineer, subsequently patented the machine for him (Fig. 2). The machine was given to and used for a time by an Edinburgh surgeon, Harold Styles, after the war.

The Patent and the information about Canon Gray were kindly given to the Department by Cardinal Gray, nephew of Canon Gray and son of Frank Gray.

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A.H.B. MASSON

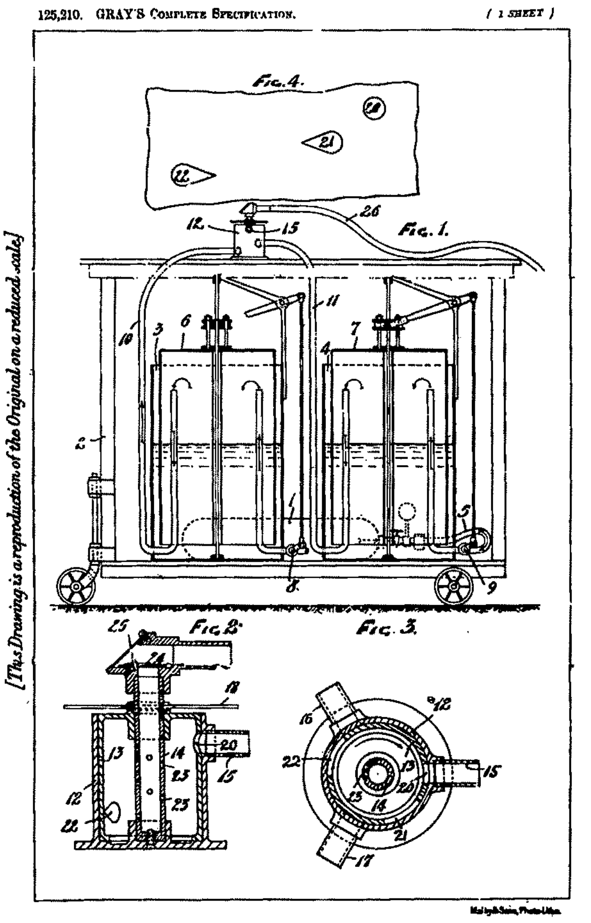
125,210. GRAY'S COMPLETE SPECIFICATION.
(1 SHEET)
[This Drawing is a reproduction of the Original on a reduced scale]
Fig. 4.
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Fig. 1

Reference

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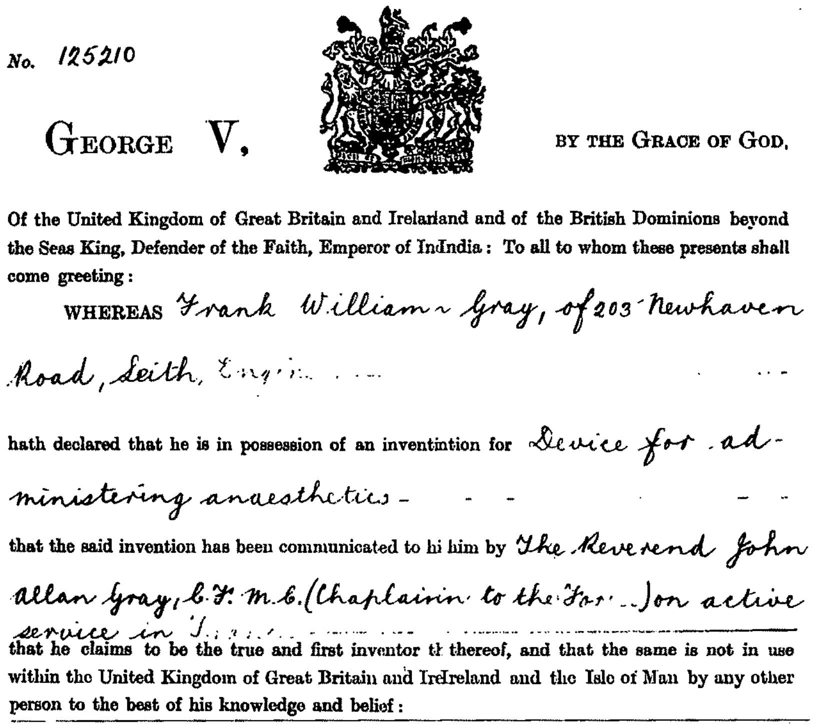

No. 125210

GEORGE V, BY THE GRACE OF GOD,

Of the United Kingdom of Great Britain and Irelarland and of the British Dominions beyond the Seas King, Defender of the Faith, Emperor of IndIndia: To all to whom these presents shall come greeting:

WHEREAS Frank William Gray, of 203 Newhaven Road, Leith, Engin...

hath declared that he is in possession of an inventintion for Device for administering anaesthetics

that the said invention has been communicated to hi him by The Reverend John Allan Gray, C.F. M.C. (Chaplainin to the For..) on active service in

that he claims to be the true and first inventor th thereof, and that the same is not in use within the United Kingdom of Great Britain and IreIreland and the Isle of Man by any other person to the best of his knowledge and belief:

Fig. 2.

Unpleasant sequelae of benzodiazepine sedation

Your correspondents (*Anaesthesia* 1989; **44:** 928) give the advice that one should ensure that a female third party is always present when drugs are given which might interfere with normal perception. This good advice has been ignored by several people using intravenous midazolam or diazepam for dental sedation and has resulted in reports of sexual fantasies occurring during sedation for which the administrator was blamed. Several of these have gone to court and as a result their right to practice was withdrawn by the General Dental Council.

Similar events after the use of benzodiazepines for sedation in dental practice, endoscopy, and induction of anaesthesia were reported,[1,2] and noted elsewhere.[3,4]

This activity has resulted in much correspondence and I now have details of 41 possible fantasies or hallucinations. Thirty-three of these occurred in women, 27 during sedation and six during the slow induction of anaesthesia. There was some element of sexual trespass in 27 of these and 20 patients found the experience unpleasant.

It was possible to verify the reports in 25 incidents and in 17 of these there was no possibility of any sexual trespass. These are similar to those described by your correspondents.

It is hoped to describe these in detail later but it is worth noting that in nine out of 13 proven fantasies the event of which the patient complained could be related to something which actually happened.

24 Old Coach Road,
Belfast,
Northern Ireland, BT9 5PR

J.W. Dundee

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Epidural pressure

The article by Johnston *et al.* (*Anaesthesia* 1989; **44:** 750–2) makes some statements which should not go unchallenged.

'The epidural pressure is an indirect indicator of cerebrospinal fluid (CSF) pressure.' This must not be taken to mean that the epidural pressure is the same as the CSF pressure, since this has been shown not to be true.[1] It is not always safe to assume that the CSF pressure in the head is the same as it is in the lumbar subarachnoid space.[2] Shah's concept that the dura mater acts as a movable membrane which allows equilibration of pressure[3] does not take all factors into account, such as the contribution made by the elastic component of the dura mater and the pressure transmitted through the internal vertebral venous plexus, which may affect the epidural pressure.

'The CSF pressure is a reflection of venous pressure.' This concept was put forward by Loman *et al.*,[4] but it was later shown by Ryder *et al.*[5] that changes in CSF pressure could occur independently of, and sometimes inversely to, changes in venous pressure. Usubiaga *et al.*[6] also demonstrated that the lumbar epidural pressure and superior vena cava pressure changes oscillate in opposite directions during normal breathing.

The concept of the elastic 'venous wall' is again from Loman *et al.*[4] The CSF is contained, in their view, between four walls; dura, arteries, capillaries and veins. The dura and arteries are rigid, so would not contribute to changes in CSF pressure, capillaries were less rigid, but veins are elastic, thus the changes in CSF pressure are secondary to changes in venous pressure. This hypothesis cannot stand in the light of our current knowledge of the structure of dura and arteries, and of the other factors which influence CSF pressure.

The suggestion that an increase in pressure on the lumbosacral veins causes a cephalad spread of CSF implies that the spinal dura mater is a rigid container which does not allow caudad spread of CSF. This does not correspond with the work of Martins *et al.*,[7] who demonstrated that the spinal dural sac is a dynamic structure, which expands and contracts in response to changes in CSF and venous pressure. Their work demonstrated that there is caudad spread of CSF when the intra-abdominal pressure is raised, but there was no evidence of a cephalad movement of CSF.

The results demonstrate an increase in epidural space pressure when posture is changed from lateral to supine. This concurs with the work of Shah[8] who produced similar results. If it is assumed, as it is by the authors, that the epidural pressure is an indirect indicator of CSF pressure, then (with the caveats above) it must be assumed that this demonstrates an increase in CSF pressure on change from the lateral to the supine position. This agrees absolutely with the work of Loman *et al.*,[4] who demonstrated the same pressure changes in the CSF.

What, therefore, is the position of the epidural veins? To ensure that the epidural veins are open requires a transluminal pressure in the veins greater than zero.[9] The inferior vena cava is 3.5 cm anterior to the anterior border of the vertebral canal in the supine position.[10] Assuming that the epidural space pressure is the pressure exerted by the dural sac on the wall of the vertebral canal, which is approximately 1.8 kPa of water in the supine position, the venous pressure in the abdomen will have to be greater than (1.8–0.35), i.e. 1.45 kPa. Whether or not this occurred is unknown, since the inferior vena caval pressure was not measured in these patients. These comments must question the validity, however, of a previous article[8] which states that the epidural veins should be engorged in the supine position on all subjects.

Overall, these workers have succeeded in measuring a change in epidural pressure with posture, but have failed to explain what these changes mean. It is hoped that in future studies the role of the internal vertebral venous plexus in the genesis of the epidural pressure and the spread of local anaesthetic solutions will be more closely examined.

Queen Elizabeth Hospital,
Birmingham B15 2TH.

G.R. Harrison

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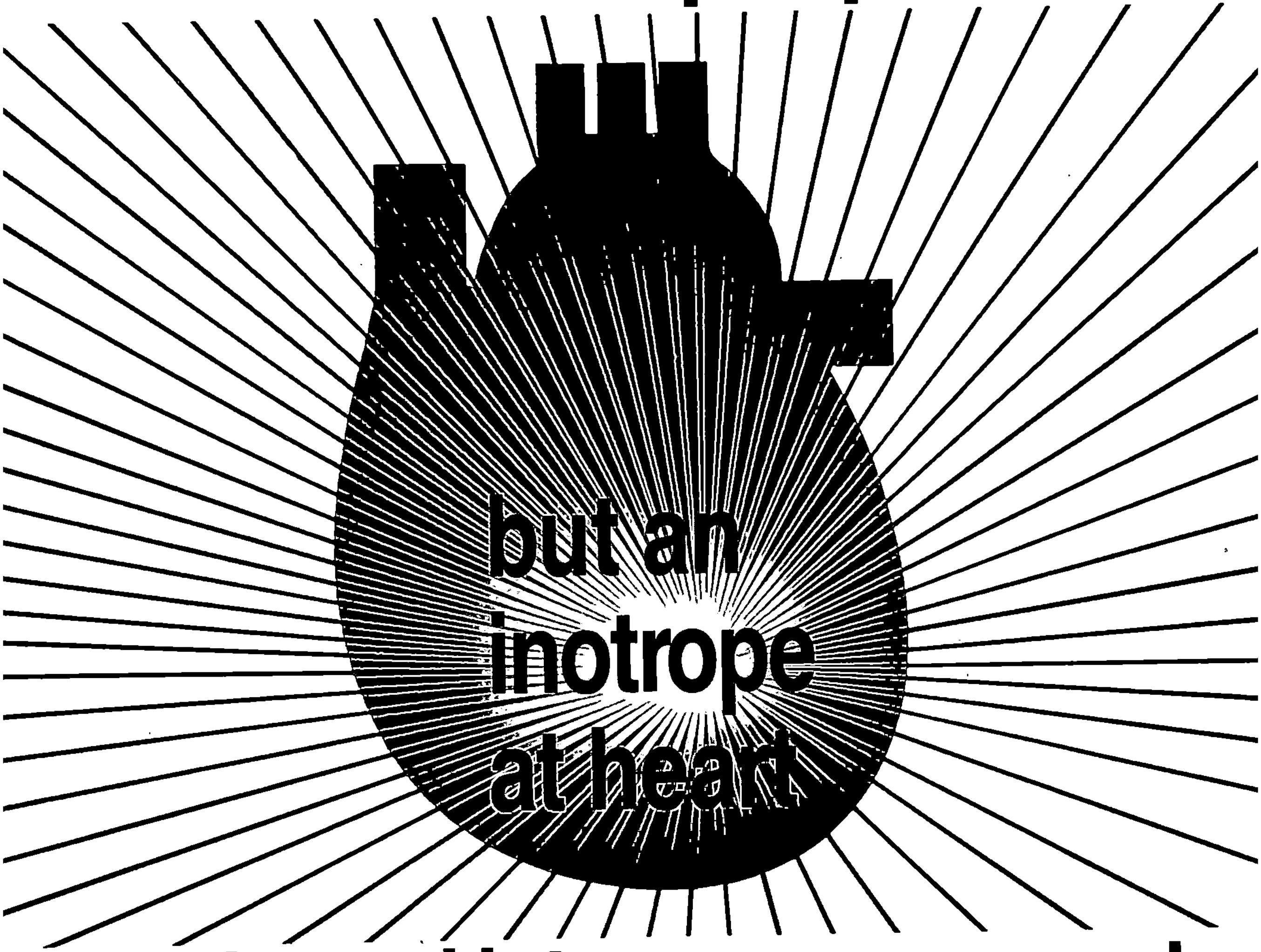

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A reply

We thank Dr Harrison for the points that he has raised about our paper. Kerr, Scott and Samuel[1] confirmed by radiological studies that it is normal for the inferior vena cava to be almost completely occluded in the supine position in late pregnancy. The venous return is redirected via collateral channels, principally the azygos and vertebral venous systems (the epidural venous plexus is part of the vertebral venous system).

There has to be a reduction in the sectional volume of the subarachnoid space when there is distension of the epidural veins by a change of posture from lateral to supine. This is achieved by upward movement of the cerebrospinal fluid towards the thoracic region where the epidural veins are not being distended.

'The epidural space pressure is an indirect indicator of CSF pressure.' We did not intend this to mean that epidural space pressure is the same as CSF pressure. There is nothing in our paper that indicates that CSF pressure in the head is the same as it is in the lumbar subarachnoid space. 'CSF pressure is a reflection of venous pressure.' We do not say that changes in CSF pressure cannot occur independently of venous pressure. The paper by Usubiaga *et al.*[2] quoted by Dr Harrison describes preferential increases between the three zones of the epidural space. They confirmed that compression of the abdominal wall increased the subarachnoid and lumbar epidural space pressure; further, it did not increase cervical epidural space pressure. This would be consistent with our hypothesis about movement of CSF.

A vein is by definition elastic if it can restore its previous bulk or shape after having been contracted or dilated. It is convenient to think in terms of a single 'venous wall' rather than countless separate small venous walls.

How can it be considered that the spinal dura mater is a rigid container? How could distension of the epidural veins influence the movement of CSF if this was the case?

We made a point of quoting Marx *et al.*[3] who showed that in the normal pregnant woman at term, in the supine position, CSF pressures are within normal limits. In other words, CSF moves away when the epidural veins become engorged. The recordings of epidural space pressure in our study were made as soon as possible after each new posture had been adopted, since it was the acute changes in which we were interested. This probably accounted for the differences in value which we found, at two separate stages in the sequence of measurements, for the posture of supine with a wedge beneath the right buttock.

Aberdeen Maternity Hospital,
Aberdeen AB9 2ZA

G.M. Johnston
R.C. Rodgers
M.E. Tunstall

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Combined supraclavicular and elbow blocks

We wish to comment on the study by Smith *et al.* (*Anaesthesia* 1989; **44:** 747–9). Their quest was to achieve prolonged postoperative analgesia without motor blockade of the shoulder after upper limb surgery and they evaluated a technique which combined supraclavicular and elbow blocks and the use of unsheathed needles. Plain solutions of 1% prilocaine and 0.5% bupivacaine were used for supraclavicular and elbow blocks respectively. Their technique is illogical and is inefficient, uncomfortable for the patient and increases the hazard of nerve injury.

A well-performed supraclavicular block provides analgesia in all three trunks of the brachial plexus, and supplemental blocks at the elbow are not usually required. The use of unsheathed needles with a nerve stimulator is a contentious point, but their routine use for blocks at the elbow (particularly ulnar block) is, in our opinion, inadvisable. The maximum current from an unsheathed needle emanates 0.5–1.0 cm proximal to the needle tip.[1] This may result in the nerve being entered by the needle before maximum stimulation occurs.[2] Furthermore, would the authors of this study consent to a procedure consisting of five injections (including intravenous access), without additional sedation?

Rather than elbow blocks, with their attendant risks and discomfort, is it not more logical simply to extend the action of the brachial block? The addition of adrenaline to bupivacaine greatly prolongs analgesia. Motor block is also extended, but as Drs Smith *et al.* state, the clinical importance of delayed return of motor function is greatly reduced by the use of 'boxing glove' or 'roller towel' dressings.

We routinely perform continuous brachial blocks using an interscalene or perivascular approach and employ intravenous cannulae modified for use with a nerve stimulator, similar in design to other workers.[3,4] Patients are usually sedated with small amounts of fentanyl and midazolam immediately before the procedure and freshly prepared bicarbonate can be added to local anaesthetic if rapid onset is desired. Analgesia can be extended well into the postoperative period and the composition of subsequent top-ups can be chosen so as to produce a selective sensory blockade.

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E. Lee
B. Ben-David

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A reply

Thank you for letting me see this letter and for the opportunity to reply to it.

Drs Lee and Ben-David appear to have missed the point of the study completely. There is no doubt that a supraclavicular block can provide excellent anaesthesia for surgery of the forearm and hand. The problem is that in the majority of cases prolonged motor block of the shoulder, upper arm and elbow is both unnecessary and unwanted. Prolonged analgesia of the operative site is usually very desirable. The drawback with continuous catheter techniques is that motor block usually persists for at least the duration of analgesia, if not longer, and clearly the patient cannot be discharged from hospital with a catheter in the plexus. Prolonged motor block does not occur with our technique and most patients leave hospital on the same day, without pain, yet retaining most of their motor functions.

We did state quite clearly, as regards the number of injections required, that the supraclavicular block was performed first. Very few patients feel anything when elbow blocks are performed and it is entirely because paraesthesiae cannot be reported that we use a nerve stimulator and pulse synchronous motor responses to aid nerve location.

The debate about the location of maximal current density with an uninsulated needle is the subject of a study to be reported shortly and we defer detailed comment until that time. We can report, however, that we strongly disagree with the conclusions of Pither *et al.*[1]

It is surprising that the writers are concerned about nerve injury at the elbow resulting from our use of 25-gauge short bevel needles, yet seem quite happy to introduce 22-gauge needles and 20-gauge cannulae into the brachial plexus. We did state that no adverse effects of the blocks were seen, nor have we seen significant nerve injury in our other patients. The suggestion that the addition of bicarbonate to bupivacaine would reduce onset time of the block was shown not to be the case for brachial plexus block over a year ago.[2] The considerable variation in quantity of bicarbonate required for adrenaline-containing solutions also makes this technique unpredictable.[3]

The writers' apparent ease in producing selective sensory blockade of the brachial plexus is hard to accept. This can be achieved to some degree in spinal block but it is almost impossible with the brachial plexus. For a drug preferentially to block the smaller fibre types it must either have low lipid solubility or be delivered in very dilute solution.[4] Most of the clinically available agents in this country have relatively high lipid solubilities and thus a dilute solution must be used, but if given by repeated top-up doses then the interval between doses is too short to be clinically practicable. However, the block is usually patchy if given by continuous infusion, and the technique becomes cumbersome.

Finally, the use of a boxing glove dressing only minimises the drawbacks of motor block in the hand and wrist; it does nothing to address the fundamental problem of motor block in the rest of the arm.

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B.E. Smith

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Reversed connexions of free-standing vaporizers

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The fresh gas flows (FGF) and the vaporizer setting determined the output after misconnexion which varied between 1.1 and 2.2 times the set value. This error increased with increasing fresh gas flows (Fig. 1). We also confirmed that the increased output was greater with a Fluotec 2 than with a Fluotec 3.

We suggest that, although in practice vaporizer settings are regulated by observation of physiological variables, the possibility of a twofold increase in output combined with the other potential problems suggests that freestanding vaporizers should be used with caution.

The Royal Melbourne Hospital,
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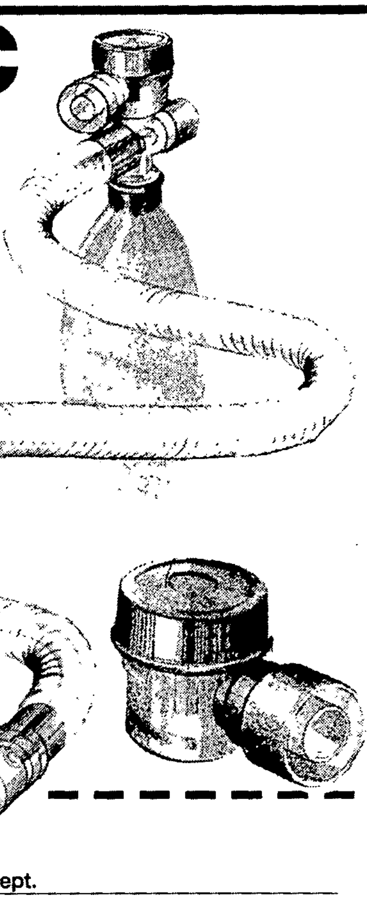

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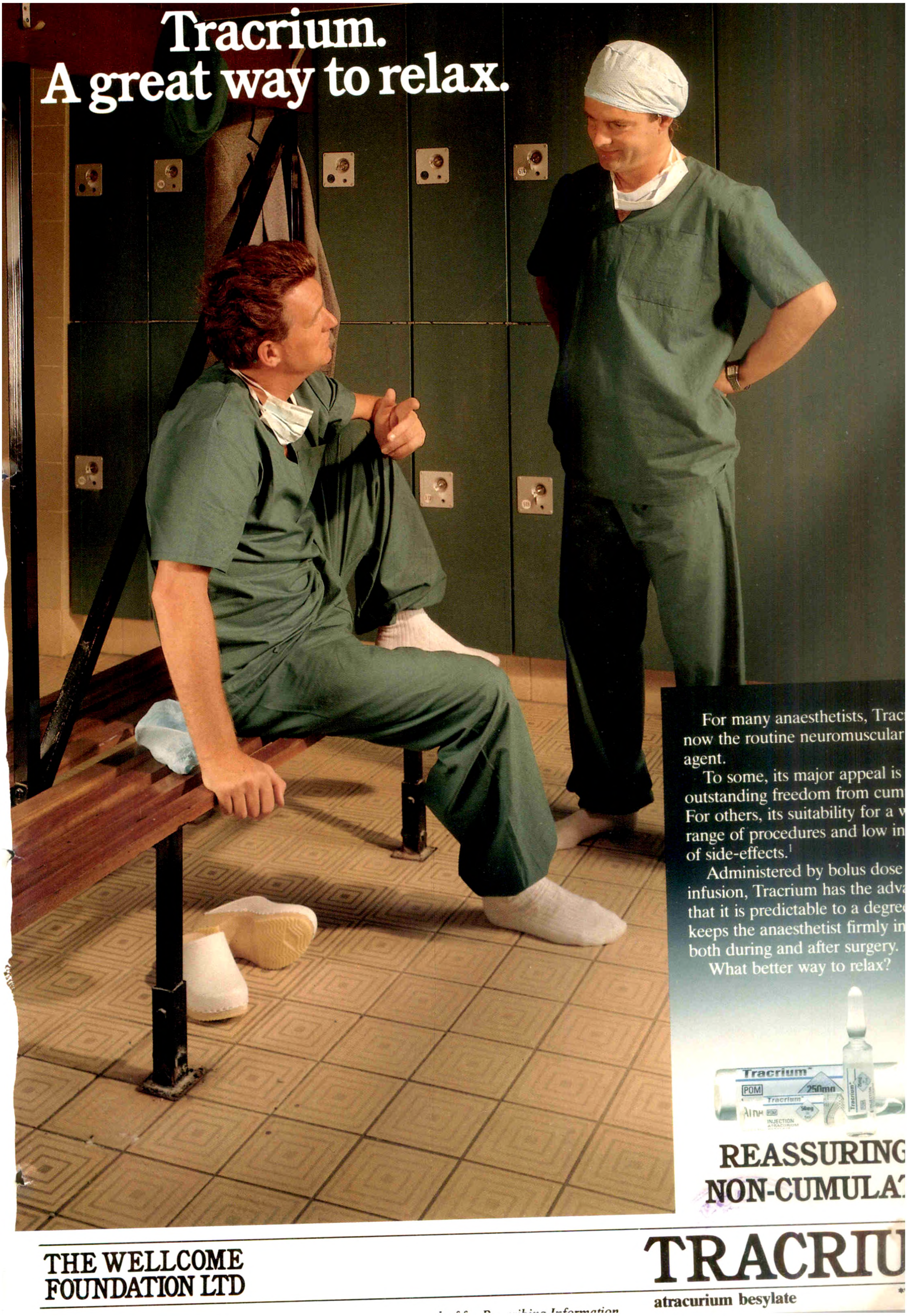

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Further information
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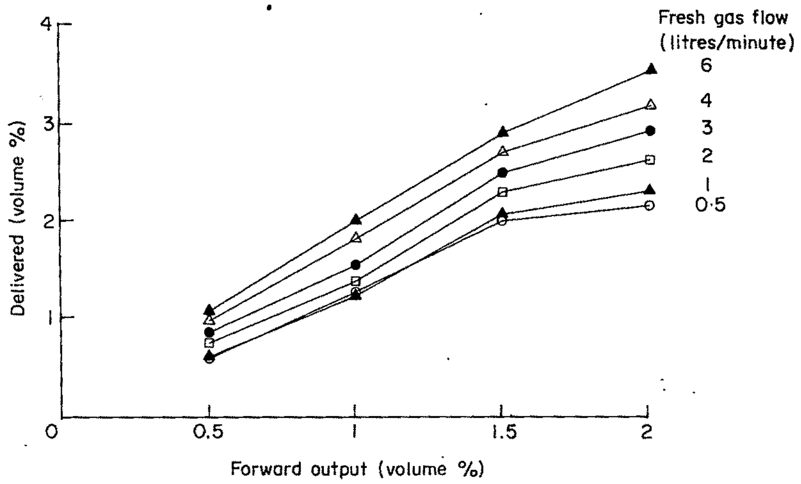

Fig. 1. Comparison of delivered output (volume % Isoflurane) with reversed and correct connexions to Isotec 3 vaporizer.

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Volatile agent use

We read with interest the investigation of Dr Tarpey and Dr Lawler (*Anaesthesia* 1989; **44:** 596–8) into the changes and perceived changes in volatile anaesthetic usage over a 3-year period in their Health District. We were stimulated to look at our department's figures to ascertain whether our experience was similar.

The pattern of change at the Royal Infirmary of Edinburgh and associated hospitals has been different from that in Cleveland. There has been a steady reduction in the use of halothane since the introduction of enflurane, with an apparent acceleration of this process in the year 1986–87, the year in which the Committee on the Safety of Medicines changed their recommendations for halothane (Fig. 1): in that year 32% fewer halothane anaesthetics were given than the previous year. Enflurane has steadily supplanted halothane, whereas isoflurane has made little impact so far.

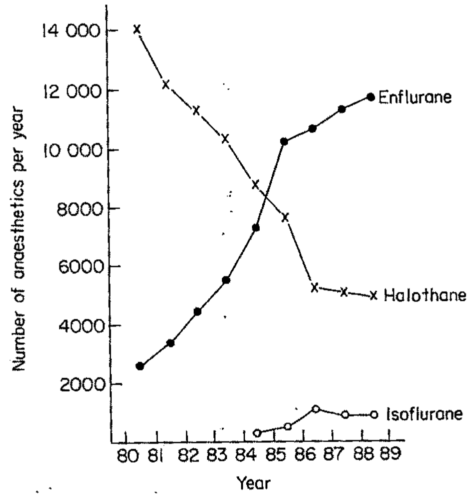

Fig. 1. The number of anaesthetics per year for halothane, enflurane and isoflurane at the Royal Informary of Edinburgh and associated hospitals.

For the year 1987–88, halothane, enflurane and isoflurane accounted for approximately 29%, 65% and 6% of volatile anaesthetics given in the Infirmary and associated hospitals. However, in terms of costs to the pharmacy for the region as a whole, halothane, enflurane and isoflurane accounted for 6%, 56% and 38% of the estimated £144 000 total bill for volatile anaesthetics: the relative costs of halothane and isoflurane to the pharmacy budget then were somewhat similar to that of Cleveland.

Our data on the pattern of volatile agent usage differ from that of Drs Tarpey and Lawler and we therefore caution against extrapolation of the experience of one locality to that which occurs nationwide.

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A reply

We thank Drs Noble and Martin for their interest in our paper and for their comments. We agree that it is inappropriate to extrapolate our findings to other Districts, or even beyond our own survey. We stated that we did not know whether the changes occurring in the 1986 year were abrupt or gradual, because, at that time, our pharmacy data were insufficiently detailed. We were also unable to obtain the data from our pharmacy suppliers, who also did not have sufficiently detailed records. Furthermore, before 1985, we did not possess District data.

We now have data for the 1988–89 year (see Table). These show a further small percentage decrease in halothane usage, with static isoflurane usage. The slack, both absolute and relative, has been taken up by enflurane. The total 'quantity' (MAC hours) of anaesthesia has also decreased, although the number of anaesthetics given is

Table. Anaesthetic delivery: South Tees Health District.

Year	MAC hours/(%)			Total number of anaesthetics	MAC hours per anaesthetic
	Halothane	Enflurane	Isoflurane		
1985–86	17 770	4495	690	21 300	1.08
	(77.4)	(18.8)	(2.9)		
1986–87	17 888	6026	1773	23 000	1.12
	(69.6)	(23.5)	(6.9)		
1987–88	12 555	6261	3335	25 000	0.89
	(56.7)	(28.3)	(15.1)		
1988–89	9925	6870	3057	25 000	0.79
	(50.0)	(34.6)	(15.4)		

virtually unchanged. We can deduce that volatile agent use has fallen, which has coincided with a further increase in propofol usage.

Halothane remains the dominant volatile anaesthetic agent used in this District (although not in Edinburgh), and this despite our perceptions. However, we can only agree with the comments concerning extrapolation of data, including our own.

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P.G.P. Lawler
J. Tarpey

Cord ischaemia

In the report of paraparesis after epidural anaesthesia (*Anaesthesia* 1989; **44:** 831–3) the possible causes of cord ischaemia were discussed, but the authors failed to mention the effect of the adrenaline 1:200 000 which was used.

Adrenaline can cause localised cord ischaemia by a local vasoconstructive action, compounded by systemic hypotension and patient posture, in those patients whose cord blood supply may be more easily compromised because of silent anatomical vascular abnormality.

The use of adrenaline with epidural bupivacaine is, in my view, totally unnecessary and may be a recipe for disaster on some occasions.

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F.F. Casale

A reply

We agree with Dr Casale that adrenaline may have further impaired cord circulation in our patient. We stated, as a matter of fact in our paper, that 'Intra-operative hypotension . . .' ('which did not require therapy') . . . 'and the use of vasoconstrictors during the anaesthetic could also have acted as ischaemic agents'. However, it should be understood that venous hypertension is thought to be the mechanism responsible for cord hypoxia in spinal dural arteriovenous fistulae, and the role of vasoconstrictors is far from established. Whatever the cause of cord ischaemia, we aimed to call attention to the rare but severe complications of epidural analgesia and we are indebted to the Editor and Dr Casale who gave us another opportunity to do so.

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Neuromuscular blockade in von Recklinghausen's disease

It is reported that patients with von Recklinghausen's disease show an undue sensitivity to suxamethonium, pancuronium and tubocurarine.[1–3] We wish to describe the use of vecuronium in a patient with this condition.

The patient was a 66-year-old man who weighed 45 kg and presented for a cataract extraction. He exhibited multiple neurofibromatoses all over his body. He had a past medical history of hypertension, epilepsy and had suffered a cerebrovascular accident that affected his left side 2 years before this admission (although he had nearly recovered from it). His current medication consisted of carbamazepine 100 mg three times a day, slow-release nifedipine 20 mg twice a day and aspirin 300 mg mane. He had no other complaints; his blood pressure was 150/90 mmHg and his electrolyte analysis was normal.

The patient was premedicated with 10 mg diazepam administered 60 minutes before operation. Monitoring was instituted on arrival in the anaesthetic room with ECG, pulse oximetry and an oscillotonometric blood pressure monitor. Anaesthesia was induced with fentanyl 2 μg/kg followed by thiopentone 250 mg. The patient's lungs were manually ventilated with 70% nitrous oxide in oxygen and 0.5% isoflurane. Neuromuscular monitoring was instituted by stimulation of the ulnar nerve percutaneously at the right wrist with supramaximal stimuli in a train-of-four mode with a peripheral nerve stimulator. The resultant force of contraction of *adductor pollicis* was measured and recorded by a force transducer and a neuromuscular function analyser (Myograph, Biometer Ltd.). Neuromuscular blockade was induced with vecuronium 0.1 mg/kg (4.5 mg) after an initial period of stabilisation and recording of the control response. The onset of complete block occurred in a relatively rapid time of 95 seconds. The first response (T1) in the train-of-four returned at 20 minutes, while the time to return of T1 to 25% of control was 34 minutes. The train-of-four ratio was greater than 75% after 60 minutes. Isoflurane was discontinued at this stage because the surgery had ended and shortly afterwards the patient started to breathe spontaneously. The patient then showed a sustained response to a tetanic stimulus at 50 Hz. Neostigmine was not administered in view of this. Soon after extubation the patient was responsive to verbal commands, able to cough well and lift his head for 5 seconds.

Previous reports of sensitivity to muscle relaxants in von Recklinghausen's disease have described both sensitivity to suxamethonium with tacrine[2] and resistance to suxamethonium by itself,[1] while sensitivity to tubocurarine and pancuronium is also described.[1,3] This case showed the onset time to maximum block with vecuronium to be more rapid than usual, but the duration of effect was within normal limits.

We were careful to use the patient's unaffected side[4] since neuromuscular monitoring may be misleading when carried out on a limb affected by a stroke.

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Humphrey ADE anaesthetic breathing system

The Humphrey ADE is an efficient anaesthetic breathing system for both spontaneous[1,2] and controlled ventilation,[3] but it is not possible to ventilate the patient's lungs manually in the D/E position because the expiratory valve does not communicate with the breathing amount and there is no route for the escape of expired gases. Manual ventilation in the Mapleson A position, though feasible, is not an efficient method of carbon dioxide elimination. Thus, there is a shortcoming with this breathing system which shows up if the ventilator breaks down or in areas where a mechanical ventilator is not available.

This problem can be overcome by a small modification. Advantage is taken of the fact that the pressure relief valve is in communication with the patient's airway *both* in Mapleson A and D/E position. The modification is achieved by replacement of this valve by one that combines an expiratory and pressure relief valve such as that used in many Bain breathing systems (Fig. 1). The original expiratory valve can then be eliminated.

The ventilator is replaced by a reservoir bag with the new expiratory valve partially closed during manual ventilation, and for controlled ventilation the bag is replaced by the ventilator, and the expiratory valve is completely closed, as is routine with the Bain breathing system. Note that in the original form it was not necessary to close the valve during controlled ventilation because it did not communicate with the breathing system.

This small modification of Humphrey ADE system makes normal ventilation in the D/E position possible and makes it more versatile without changing the basic function.

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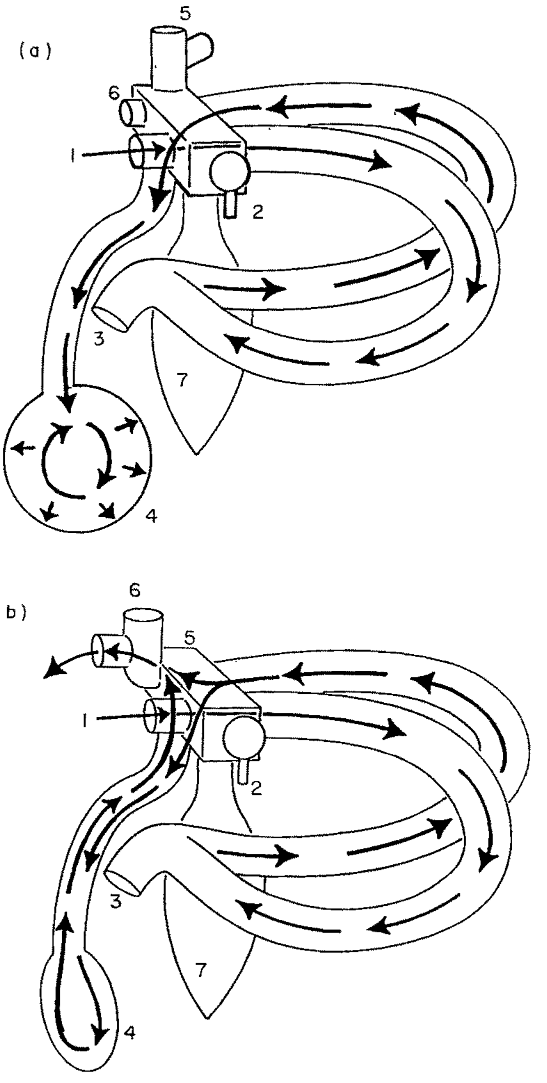

Fig. 1. (a) Humphrey ADE; (b) modified Humphrey ADE. 1. Fresh gas flow; 2. Mode change in D/E mode; 3. Patient end; 4. Reservoir bag; 5. Expiratory valve, eliminated in modification (b); 6. Pressure relief valve replaced by combined expiratory and pressure relief valve in modification (b); 7. Reservoir bag in A mode.

Pneumothorax after interpleural block in a spontaneously breathing patient

Interpleural analgesia is an accepted mode of pain relief in postsurgical and trauma patients.[1-3] Reiestad and coworkers found no pneumothorax by chest X ray in any of their 81 subjects.[1] Most cases of pneumothoraces are reported in patients whose lungs are ventilated or during placement of an intravenous catheter.[3,4]

A 28-year-old healthy female had an emergency cholecystectomy under standard general anaesthesia. She was awake and breathing spontaneously in the postanaesthetic recovery room and was in the left lateral decubitus position. A single-shot interpleural block was administered above the level of the seventh rib in the posterior axillary line with a 16-gauge Tuohy needle. The patient moved unexpectedly during the administration of 35 ml bupivacaine 0.5% with adrenaline 1:200000. A chest X ray demonstrated a 25% right-sided pneumothorax, but the patient had no symptoms and vital signs remained stable; complete analgesia was attained. There were still no signs or symptoms of respiratory or cardiovascular compromise 5 hours later and a repeat X ray showed no increase in interpleural gas volume. The patient was subsequently transferred to the ward with oxygen and no supplemental analgesics were required for the next 12 hours. The remainder of her stay in hospital was uneventful.

Pneumothorax is a well known but infrequent complication of interpleural neural blockade, although the exact incidence is unknown. This problem is reported twice,[3,4] but in these cases mechanical ventilation was in use during placement of the interpleural catheter. Our clinical experience agrees with that of previous studies which state that this block provides analgesia of equal duration to intercostal neural blockade but is far simpler to perform.[1,2] This is the first complication we have experienced with this technique without catheter placement in a small series of 30 patients. The advantages of the single shot are its relative ease, avoidance of the theoretical complications of placing an interpleural catheter (e.g. empyema) and lack of resistance during injection which virtually guarantees intrathoracic placement of the local anaesthetic. The disadvantages, as demonstrated in this report, include the inability to both withdraw air or to administer top-up doses for prolonged analgesia.

We consider that the needle should be placed during expiration and a smaller gauge needle, 19–20 Tuohy, instead of 16 or 17, should be used in order to minimise the volume of air trapped.

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A possible hazard

It is a routine practice here to warm patients actively using overhead 'thermal ceiling' (radiant heat supply) after cardiac surgery. This was shown to be effective and prevents some of the hazards associated with passive warming of patients.[1,2]

We have, however, encountered a problem which is worth remembering. The Hewlett Packard System for patient monitoring (Model Merlin M1166A/A68) measures cardiac output by the thermodilution principle, wherein the temperature of the injectate should be at, or below, room temperature. The practice in our institution is to use injectate at room temperature and this is supported by previous studies[3]. With the use of the thermal ceiling where the temperature is about 37°C, the tubes leading to the port of injection are also warmed to this temperature and the monitoring system is unable to determine cardiac output. This is an obvious hazard in a critical situation where rapid determination of cardiac output is essential for proper patient management. The system has often failed.

We recommend that in all patients who are warmed artificially using these thermal ceilings, cardiac output determinations using the thermodilution catheter should ensure that facilities for continuous maintenance of steady-state temperature of injectate be available. Such a device is the CO-Set (Baxter) and although promoted as an effective infection control system, it also ensures constant, correct injectate temperature determination.[4]

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Half a guard is better . . .

Inadvertent damage to teeth or gums associated with laryngoscopy is distressing for a patient and may be expensive to correct. Proper care is, therefore, absolutely necessary.[1] Inconvenient methods tend, unfortunately, to be abandoned when difficulties arise during intubation. We have tried the transparent gumshield (*Anaesthesia* 1989; **44:** 705) which, while it provides adequate protection for the teeth, does restrict access. We suggest the use of a modified Bite-guard (Medasil Surgical Ltd, Leeds), with one-third to one-half of the right-hand side removed (Fig. 1). Laryngoscopy, facilitated by a smear of lubricant, is made easy. Vision is unimpaired and the maximum space is available for manipulation and passage of a tracheal tube. A length of suture secures against displacement or loss. Half a Bite-guard is very much better in our experience than no guard at all.

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M.J. Leadbeater
M.R. Nott

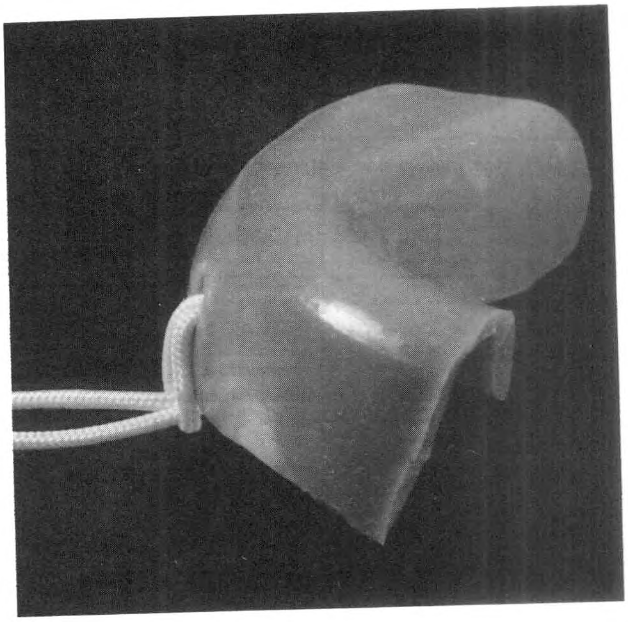

Fig. 1.

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Creasing of a paediatric tracheal tube connector

Plastic 8.5-mm tracheal tube connectors are widely used in paediatric anaesthetic practice. This report describes a problem with one such connector.

Anaesthesia for inguinal herniotomy was induced in a 6-week-old baby with nitrous oxide, oxygen and halothane. Controlled ventilation of the lungs was easily achieved and after the administration of suxamethonium, oral intubation performed with a 3.0-mm blue line Portex tracheal tube on an 8.5-mm plastic connector. Manual ventilation via the tracheal tube, though possible, was difficult and it was immediately removed. The child could easily be ventilated both by facemask, and when re-intubated with another tube of the same size.

Later inspection of the first tracheal tube revealed the abnormalities shown in Figure 1. The wall of the tapered section of the 8.5 mm connector had become creased so that the lumen was partially occluded; furthermore, the remaining space was partly blocked by dried lubricating jelly, used to aid assembly. Neither of these problems was apparent from an external inspection of the tube, but both would have been revealed had the tube been examined by looking through it along its long axis.

A similar problem was previously reported to Portex UK Ltd. and was attributed to excessive twisting during insertion of the connector into the tube. As a consequence, moulding modifications were implemented to increase the connector wall thickness. It is, unfortunately, not possible to determine whether the connector involved in this incident was manufactured before or after this change.

Lubricant jellies are frequently used to aid the insertion of introducers into tracheal tubes. However, when the stylet is removed a proportion undoubtedly remains within the tube, and may be dried by the passage of anaesthetic gases to form a crust, and partially block the lumen.

It would seem sensible to recommend that care is taken when Portex paediatric tracheal tubes are joined to their connectors, that lubricant jellies are avoided, and that an internal visual inspection is undertaken before use to ensure patency.

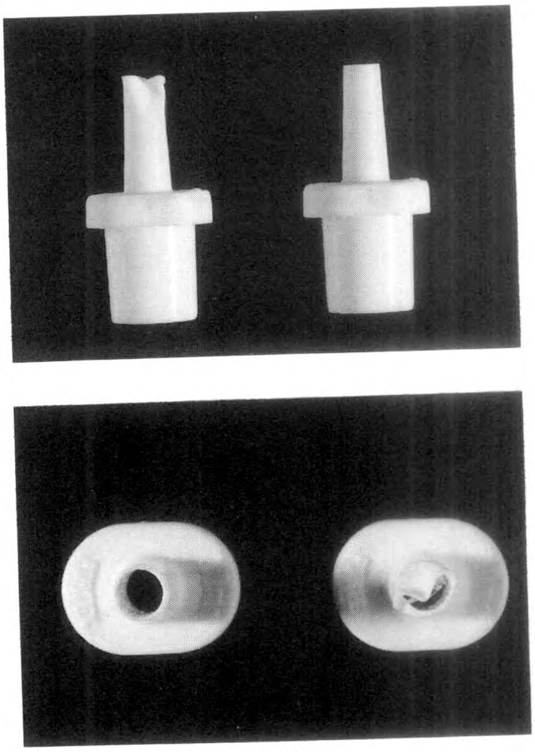

Fig. 1.

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A.J. Sansome

An unusual complication of a central venous line

It is the practice of this hospital to insert two 60-cm 16-G Wallace piggy back central venous catheters via the right internal jugular vein in patients who have coronary artery bypass graft (CABG) surgery. The catheter is threaded through a 14-G plastic cannula and at no stage comes into contact with sharp needles. The use of the long length catheter enables easy access for drug administration (rather than have to search for the end under surgical drapes) but carries the risk of the insertion of too great a length of catheter.

Recently, difficulty was experienced in removing one of these such catheters. The patient had routine CABG and 24 hours after operation one of the catheters was taken out uneventfully; the remaining catheter was 'stuck' and could not be removed: aspiration and flushing were normal and a chest X ray showed the tip of the catheter to be in the right atrium and there were no kinks or knots. A 'J'-shaped wire was fed halfway down the catheter to provide extra support and an extra hard pull was applied to the catheter which came free, revealing a torn but complete end (Fig. 1). It appears that the catheter tip was positioned in the right atrium during surgery and had probably lain close to the venous cannula inserted for bypass. The catheter tip had then been ensnared in the purse string suture which closed the right atrial appendage and made its removal somewhat difficult.

Complications with central venous catheter insertion are numerous; this is another, albeit rare, complication on removal.

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H.M. Monro

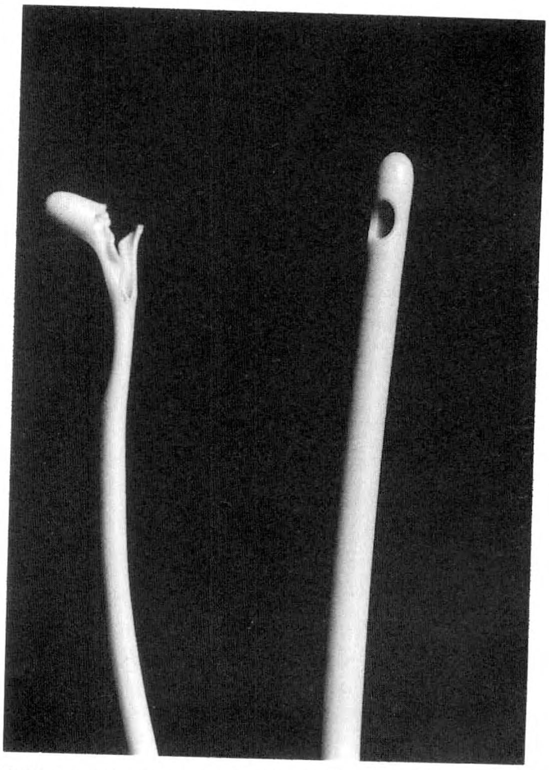

Fig. 1. Damaged catheter on the left compared with normal one on the right.

Pulse oximetry—another problem

Pulse oximetry is a valuable form of monitoring in paediatric practice.[1] However, the amount of paediatric anaesthesia undertaken in District General Hospitals may be small and require the adaptation of existing adult monitors for use in children. The Hewlett Packard oximeter probe is designed for a large range of finger sizes, but children's fingers may be too short to reach the light source and detector. The distal end of the probe has a slit which is designed to accommodate long finger nails and to avoid one cause of inaccurate oximeter readings.[2]

The slit in the distal end of the probe allows children's fingers to reach the light source and detector. Unfortunately, this may produce an inaccurate oximeter reading if the pressure exerted by the probe on the finger produces either venous congestion or a reduction in arterial perfusion. This problem may be overcome by splinting the extensor aspect of the finger with a 3-cm long hemisection of the barrel of a 2-ml syringe (Fig. 1).

There can be no doubt that the ideal situation is to have specifically designed paediatric equipment. However, there will continue to be situations when easily reversible adaptations of adult equipment are required for children. This is a simple modification of the Hewlett Packard probe which we have used to provide accurate pulse oximetry for children in a situation in which the alternative would be no oximetry.

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L.F. Marks
P.J. Heath

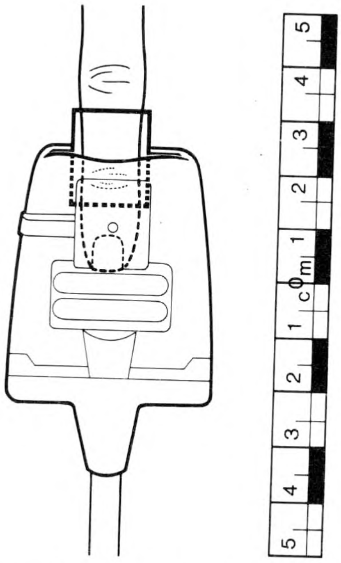

Fig. 1. Oximeter probe with finger and 2 ml syringe barrel *in situ*.

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Anaesthesia, 1990, Volume 45, pages 345–346

Book reviews

Techniques of regional anaesthesia 345
D. Bruce Scott

Capnography in clinical practice 346
J.S. Gravenstein, D.A. Paulus and T.J. Hayes

Techniques of regional anaesthesia

D. Bruce Scott. Pp. 244. Appleton and Lange/Mediglobe, 1989. £69.00.

This text is the successor to the deservedly popular *Illustrated handbook in local anaesthesia* edited by Ejnar Eriksson which first appeared 20 years ago. That Eriksson's book is no longer up-to-date enough for modern practice is not in doubt, and several rival texts have appeared since 1979 and the last edition. The longevity of Eriksson and its almost universal popularity was due in the main to the illustrations by Poul Buckhoj. It has been virtually compulsory for any book of regional anaesthesia since then to have illustrations by Mr Buckhoj or by another artist working to comparable standards.

The author of this book asks in the Preface, in effect, why this book was necessary when several similar books are available. Never one to refuse an opportunity for idle speculation, I suggest that since Dr Scott is unlikely to have needed the money, probably he was spurred on by the fact that a large number of illustrations by Mr Buckhoj were available already in other books by the same publisher, and a couple of deals made the production of the new book a great deal easier. In addition, I would not mind wagering the price of a decent meal that the company owning the copyright to nearly five dozen of the illustrations used also has a major interest in this publisher. Casting aside evil speculation, which is fuelled by the wish that I would like to have been able to write it myself, there are two questions to answer. Is this book a suitable replacement for Eriksson and is it worth buying? The answer to the first part is an unhesitating yes; the answer to the second is more difficult and will depend upon several factors

Eriksson suffered from over simplicity and the beauty of the illustrations diverted attention from sparse and, at times, inaccurate text. Dr Scott has improved matters greatly and attempted to produce the ultimate regional anaesthetic cookbook with the text on the left-hand page and illustrations on the right. This has resulted in a very stylish layout, but there is still the odd wart, to this reviewer's eye. No less than six other textbooks have provided Buckhoj illustrations for this text and it is interesting to see how his style has changed over the years.

Dr Scott makes some fundamental changes from previous work in the Introduction. He has redefined the dose range of the commonly used agents, re-espoused the test dose and does not seem to believe there is benefit in supplementary oxygen or oximetry. There follows a good section on methods of topical anaesthesia which includes a section on anaesthesia for arthroscopy of the knee. Those who attempt this block will find it works extremely well, but it is advisable to mark the anaesthetised areas of skin otherwise surgeons will cut an unanaesthetised area wherever possible unless they are given clear instructions. There is also mention of topical anaesthesia for removal of molluscs (p32) which will come in handy when one is attacked by a crazed whelk.

The next section is on peripheral nerve block, and is good value for the most part. Personal prejudice influences my comment that the needles illustrated seem very large and also that aspirating syringes and an isolated needle are mandatory for many of the blocks illustrated, but this may reflect my inherent conservatism. There is a redundant illustration in the section on cervical plexus block and this happens elsewhere. There are also problems throughout the book of matching the text to the illustration.

It is a pleasure to record that there are descriptions of knee blocks, foot blocks and interpleural anaesthesia. On the debit side, in addition to other minor points, serious reservations must be expressed about the method of intercostal blockade illustrated. This shows an approach not dissimilar to that employed by Brutus when about to have a brief word with Julius Caesar.

The book is concluded with sections on central blockade, sympathetic block and the use of local anaesthetic techniques for postoperative pain relief. The section on central blockade contains chunks from Dr Scott's text on epidural anaesthesia and it would remain difficult to identify the sacral hiatus if one followed the text, but very easy if you look at the pictures. Unfortunately the text does not help to explain the picture. The reader may be more confused to find that 0.75% bupivacaine in 8.25% glucose is hypobaric, and on the next page is a large and beautiful illustration not mentioned anywhere in the text.

Personal practice colours my view of the section on sympathetic blockade. Radiological control is mandatory for any neurolytic block; I would use half the volume of phenol described for lumbar sympathectomy and would never do bilateral blockade at the same time. Having experienced most of the known complications of stellate ganglion block either personally or in my patients I hold strong views about the performance of this block. If I caught anybody trying to perform a stellate ganglion block in the manner shown on p209 I would break his or her arm. This should have a health hazard warning notice attached to it and I believe that this is one block where an isolated needle is mandatory as is a tiny test dose. There is nothing quite like a quick convulsion to remind you of the anatomy of the vertebral artery. The final section on postoperative pain relief is brief but most welcome.

To return to the question of whether or not you should buy it. This will depend upon whether you want a reference book or a cookbook; it will depend upon whether you have one or more of the contributory texts and whether or not you own recent editions of the rival texts. The quality of this book, despite its flaws, is high and the illustrations are, as ever, outstanding. It is not a reference book and does not attempt to compete with texts that are. It will complement these and will find its place in much the same way as Eriksson did, as the standard *illustrative* text for those teaching and learning regional anaesthetic techniques. As such it should be in departmental libraries where individuals can browse through it before making a decision about individual purchase. Personally, I would buy it like a shot—warts and all!

J.E. Charlton

Capnography in clinical practice

J.S. Gravenstein, D.A. Paulus and T.J. Hayes. Pp. x+158. Butterworth, 1988. £21.95.

This book had its origins in the Autumn of 1985 when the Anesthesia Patient Safety Foundation recognised the need for greater educational efforts in the promotion of understanding of capnography. Originally formulated as a manual to accompany a teaching videotape, the text and content were expanded to become the current volume. A concise text on capnography is timely, and most of the larger standard works do not give sufficient weight to the subject.

The authors state clearly that they had no intention of producing an encyclopaedic text, and the book is divided into three parts. The first deals with clinical aspects of capnography: the shape of abnormal capnograms, and indications for use; the second considers the physiology of carbon dioxide production and transport; and the third describes the different physical methods of measurement and their associated problems. The authors do not state their target audience specifically, but it can be inferred from the preface to be the practising clinician.

The first and third parts of the book are well written and have a good factual content. In general the relevant arguments are presented logically and clearly although occasionally the authors' personal opinions do slip through. Many practising British anaesthetists would find useful information from a perusal of sections one and three of this book: furthermore, the content of these parts is likely to be more than adequate for registrars preparing for the College examinations.

Unfortunately, I cannot be as complimentary about the second part of the book. Information on the physical properties of carbon dioxide and its physiology is available in many other texts and is probably insufficiently detailed for final Fellowship candidates. Judged from a European perspective the chapter on ventilation/perfusion ratios deals rather briefly with the contribution of Fletcher and co-workers, and contains several unsupported statements. Is it true for instance (page 88) that 'a tidal volume delivered by mechanical ventilation to a paralysed patient is less likely to raise carbon dioxide from the depth of the furthest alveolus than is a deep spontaneous breath of equal tidal volume'?

The book is well referenced throughout and does not, as many American texts do, include publications solely from the New World.

In summary, given the reservations about section two, this monograph is a valuable addition to the current anaesthetic literature which many anaesthetists may wish to purchase for themselves or their departmental libraries. Locally, my review copy has disappeared without trace, so one person at least must be finding it a good read!

P. Hutton

Anaesthesia, 1990, Volume 45, pages 347–348

Obituaries

Burns, T.H.S., MA, BM, BCh, FFARCS, formerly Consultant Anaesthetist at St Thomas' and Royal Northern Hospitals. Qualified from Oxford.

Curtin, F., MB, BCh, FFARCS, formerly of Co. Dublin.

Dallas, S.H., MA, MB, BChir, FFARCS, DA, DObstRCOG, formerly Consultant Anaesthetist at Smethwick and Sandwell Area Health Authority. Qualified from University of Cambridge in 1952.

Davidson, L.D., MB, BCh, FFARCS, DA, formerly Consultant Anaesthetist at Aberdeen. Qualified from University of Aberdeen in 1945.

International congress calendar

1990

2–6 April. Oxford. *Course in Clinical Neurophysiology.*
Information: Dr K.R. Mills, Clinical Neurophysiology Unit, University Department of Clinical Neurology, The Radcliffe Infirmary, Oxford, OX2 6HE.

4–6 April. Glasgow. *Junior Anaesthetists' Group of the Association of Anaesthetists of Great Britain and Ireland. Linkman Conference and Annual Scientific Meeting.*
Information: Honorary Secretary, Association of Anaesthetists of Great Britain and Ireland, 9 Bedford Square, London, WC1B 3RA.

9–12 May. Vienna. *Third International Symposium on Echocardiography and Doppler in Cardiac Surgery.*
Information: G. Maurer, W. Mohl, c/o Interconvention, A–1450 Vienna, Austria.

13–16 May. Vienna. *5th Annual Meeting European Association of Cardiothoracic Anaesthesiologists.*
Information: Professor W. Haider, Department of Cardiothoracic Anaesthesia and Intensive Care, Spitalgasse 23, A–1090 Vienna, Austria.

13–19 May. Wellington, New Zealand. *Faculty of Anaesthetics and the Royal Australasian College of Surgeons Annual General Meeting.*
Information: Administrative Officer, Faculty of Anaesthetists, RACS, Spring Street, Melbourne, Victoria 3000, Australia.

16–18 May. Southampton. *Blood Vessel Imaging Using Ultrasound Techniques.*
Information: Mr K.N. Humphries, Blood Vessel Imaging Course, 10 Swale Drive, Chandlers Ford, Hampshire, SO5 3QY, UK.

17–20 May. San Francisco. *California Society of Anesthesiologists Annual Meeting.*
Information: California Society of Anesthesiologists, 1065 East Hillsadale Boulevard, suite 410, Foster City, California 94404, USA.

28 May–1 June. Montreal. *McGill University Annual Review Course in Anaesthesia.*
Information: Post Graduate Board, Royal Victoria Hospital, 687 Pine Avenue West, Room H308, Montreal, Quebec, H3A 1A1, Canada.

5–8 June. Amsterdam. *5th European Congress on Intensive Care Medicine 1990.*
Information: Secretariat, c/o Holland Organizing Centre, Lange Voorhout 16, 2514 EE, The Hague, The Netherlands.

8–11 June Colorado. *Thirteenth Annual Conference on Shock.*
Information: Dr Sherwood M. Reichard, Shock Society, Medical College of Georgia, 1120 15th Street, Augusta, GA 30912, USA.

15–19 June. Vancouver. *47th Annual Meeting of the Canadian Anaesthetists' Society.*
Information: Ms Ann Andrews, CAS 187, Gerrard St. E, Toronto, Ontario M5A 2E5 Canada.

5–8 September. Budapest, Hungary. *3rd International Symposium on Anesthesia for Cardiac Patients.*
Information: Dr G. Silvay, Department of Anesthesiology, Box 1010, Mount Sinai School of Medicine, 1 Gustave L. Levy Place, New York, NY 10029-6574, USA.

9–15 September. Warsaw. *VIIIth European Congress of Anaesthesiology.*
Information: The Organising Committee, VIIIth European Congress of Anaesthesiology, c/o The Polish Society of Anaesthesiology and Intensive Therapy, ul. Kasprzaka 17a, 01-211 Warsaw, Poland.

14–18 June. Paris. *New Approaches to Pulmonary Ventilation.*
Information: Professional Seminars Inc., P.O. Box 012318, Miami, Fl. 33101, USA.

22–24 August. Edinburgh. *Edinburgh Anaesthesia Festival.*
Information: Dr C.J. Sinclair, Department of Anaesthetics, Royal Infirmary, Edinburgh, EH3 9YW.

23–28 September. Seoul. *8th Asian/Australasian Congress of Anaesthesia.*
Information: Department of Anesthesiology, Seoul National University Hospital, 28 Yungun-Doug, Chongro-Ku, Seoul 110, S. Korea.

25–28 September. London. *Ultrasound Angiography.*
Information: The Conference Secretariat, P.O. Box 15, Eastleigh, Hampshire, SO5 5XG.

26–28 September. Manchester. *Linkman Conference and Annual Scientific Meeting.*
Information: The Honorary Secretary, Association of Anaesthetists of Great Britain and Ireland, 9 Bedford Square, London, WC1B 3RA.

19–23 October. Las Vegas. *American Society of Anesthesiologists Annual Meeting.*
Information: Executive Secretary, ASA, 515 Busse Highway, Park Ridge, IL 60068, USA.

3–4 November. New York. *28th Annual Bernard H. Eliasberg Memorial Symposium.*
Information: Anita Guffin, MMS, Mount Sinai Medical Center, One Gustave Levy Place, New York, New York 10029, USA.

5–10 November. Sao Paulo. *36th Brazilian Congress of Anesthesiology.*
Information: Dr R. Mathias, Rua Caiubi 666, Sao Paulo, Brazil 05010.

7–9 November. Israel. *Fourth International Symposium of Anaesthesia and Intensive Care.*
Information: Dr G. Gurman, Division of Anaesthesiology, Soroka Medical Centre, Beer-Sheva 84101, Israel.

18–21 November. Kyoto, Japan. *4th International Symposium on the Pain Clinic.*
Information: 4th WSPC Secretariat, Department of Anesthesiology, Osaka Medical College, c/o Inter Group Corp., Shohaku Bldg., 6–23 Chayamachi Kita-ku, Osaka 530, Japan.

5–9 December. San Juan. *15th Caribbean Symposium in Anaesthesia and Related Fields.*
Information: Miguel Colon-Morales, GPO Box 4547, San Juan, Puerto Rico 00936.

8–12 December. New York. *Forty-fourth Postgraduate Assembly in Anesthesiology.*
Information: Kurt G. Becker, Executive Director, The New York State Society of Anesthesiologists Inc., 41 East 42nd Street, Suite 1605, New York 10017, USA.

1991

10–13 January. Miami. *28th Annual Post-Graduate Seminar in Anesthesiology.*
Information: Barbara McNulty, Continuing Education Programs, 7480 Fairway Drive, Suite 106, Miami Lakes, Florida 33014, USA.

2–9 February. Colorado. *17th Annual Vail Conference in Anesthesiology.*
Information: Sonja Craythorne, Professional Seminars, P.O. Box 012318, Miami, Florida 33101, USA.

8–12 March. San Antonio. *65th Congress of the International Anesthesia Research Society.*
Information: Emerson A. Moffitt, IARS, 3645 Warrensville Center Road, Cleveland, Ohio 44122, USA.

3–5 April. Oxford. *Junior Anaesthetists' Group of the Association of Anaesthetists of Great Britain and Ireland Linkman Conference and Annual Scientific Meeting.*
Information: Association of Anaesthetists of Great Britain and Ireland. 9 Bedford Square, London, WC1B 3RA.

15–18 April. Hamamatsu, Japan. *6th International Symposium on Computing in Anesthesia and Intensive Care.*
Information: Dr K. Ikeda, Chairman of the Organizing Committee, c/o Department of Anesthesiology, Hamamatsu University School of Medicine, 3600 Handa-cho, Hamamatsu, Shizuoka, 431–31 Japan.

1–4 May. Montreal. *2nd International Symposium on Pediatric Pain.*
Information: Pain Secretariat, 3450 University Street, Montreal, Quebec H3A 2A7, Canada.

3–5 May. Philadelphia. *AUA Annual Meeting.*
Information: Stephen J. Prevoznik, Department of Anesthesia, Hospital of the University of Pennsylvania, 3400 Spruce Street, Philadelphia, Pennsylvania 19104, USA.

9–12 May. Washington DC. *6th International Dental Congress on Modern Pain Control.*
Information: American Dental Society of Anesthesiology, Inc., 211 E. Chicago Avenue, Suite 948, Chicago, IL 60611, USA.

24–25 May. The Netherlands. *Receptors of the Brain, Lung and Heart: State of the Art.*
Information: Cader Research B.V., P.O. Box 85, 4854 ZH Breda/Bavel, The Netherlands.

27–31 May. Montreal. *McGil University Annual Review Course in Anaesthesia.*
Information: Post Graduate Board, Royal Victoria Hospital, 687 Pine Avenue West, Room H308, Montreal Quebec, H3A 1A1, Canada.

21–25 June. Quebec City. *48th Annual Meeting of Canadian Anaesthetists' Society.*
Information: Ms Ann Andrews, CAS, 187 Gerrard St. E., Toronto, Ontario M5A 2E5, Canada.

11–13 September. Harrogate. *Linkman and Annual Scientific Meeting of Association of Anaesthetists of Great Britain and Ireland.*
Information: Association of Anaesthetists of Great Britain and Ireland, 9 Bedford Square, London, WC1B 3RA.

26–30 October. San Francisco. *American Society of Anesthesiologists Annual Meeting.*
Information: Executive Secretary, ASA, 515 Busse Highway, Park Ridge, IL 60068, USA.

7–11 December. New York. *Forty-fifth Postgraduate Assembly in Anesthesiology.*
Information: Kurt G. Becker, Executive Director, The New York State Society of Anesthesiologists Inc., 41 East 42nd Street, Suite 1605, New York 10017, USA.

1992

1–8 February. Colorado. *18th Annual Vail Conference in Anaesthesiology.*
Information: Sonja Craythorne, Professional Seminars, P.O. Box 012318, Miami, Florida 33101, USA.

13–17 March. San Francisco. *66th Congress of the International Anesthesia Research Society.*
Information: International Anesthesia Research Society, 3645 Warrenville Center Road, Cleveland, Ohio 44122, USA.

29 March–2 April. Atlanta, Georgia. *The Third International Symposium on the History of Anaesthesia.*
Information: R.K. Calverley, Medical Center, University of California, 225 Dickinson Street, San Diego, California CA 92103, USA.

12–19 June. The Hague. *10th World Congress of Anaesthesiology.*
Information: Dr Harm Lip, Nilantsweg, 99, 8041 AR Zwolle, Netherlands.

17–21 October. New Orleans. *American Society of Anesthesiologists Annual Meeting.*
Information: Executive Secretary, ASA, 515 Busse Highway, Park Ridge, IL 60068, USA.

12–16 December. New York. *46th Postgraduate Assembly in Anesthesiology.*
Information: Kurt G. Becker, Executive Director, The New York State Society of Anesthesiologists, Inc., 41 East 42nd Street, Suite 1605, New York 10017, USA.

1993

12–16 February. Utah. *38th Annual Postgraduate Course in Anesthesiology — 'Anesthesiology: Today and Tomorrow'.*
Information: Vicky Larson, Department of Anesthesiology, University of Utah School of Medicine, 50 North Medical Drive, Salt Lake City, Utah 84132, USA.

29 April–2 March. North Carolina. *Meeting of the Association of University Anesthetists.*
Information: Francis M. James III, Department of Anesthesia, Wake Forest University Medical Center, 300 S. Hawthorne Road, Winston-Salem, North Carolina 27103, USA.

15–17 September. Glasgow. *Joint Meeting between the Association of Anaesthetists of Great Britain and Ireland and the Canadian Anaesthetists' Society.*
Information: The Honorary Secretary, Association of Anaesthetists of Great Britain and Ireland, 9 Bedford Square, London, WC1B 3RA.

9–13 October. Washington DC. *American Society of Anesthesiologists Annual Meeting.*
Information: Executive Secretary, ASA 515 Busse Highway, Park Ridge, IL 60068, USA.

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Safety Action Bulletin

Vickers Medical Travenol Treonic C30 Infusion Controller Model 110: Control Lever Arm Modification (89) (90)

This modification requires to be done but the programme is not yet fully completed. All users are advised to check that their Treonic C30 Infusion Controllers are not in need of modification. If in doubt, they should contact S and W Vickers.

Vickers Medical IP3 Syringe Pump (89) (91)

Precautions are necessary in the use of these pumps in order to avoid over or under infusions. A 50/60 ml Beckton Dickinson Plastipac syringe should be used. The infusion rate should be double-checked. This should be done when the switch cover is closed. If the switches for rate control are in any way contaminated the pump should be sent immediately for service.

This syringe pump is not an up-to-date design and has no internal power source in the event of mains failure. It is not recommended for neonatal or high risk infusions.

Hazard Notice

Intravascular Sheath (catheter) Introducer Set product nos beginning TSS and TSSN . . .

All sizes manufactured on or after 3 May 1989 by William Cook (Europe) Ltd: **product recall.**

These may leak and according to Hazard Notice (HC (Hazard) 89) (42) should be withdrawn from use.

Apology

Readers may have noticed the publication (*Anaesthesia* 1989, **44:** 929–30) of an identical photograph and two similar paragraphs in the text to material published in *Anesthesiology*, (1989; **71:** 621–22). The Editor and the authors apologise for this which occurred for fully understandable reasons.

Sumner & Hatch

Edward Sumner, Chairman, Division of Anaesthetics; & David J. Hatch, Consultant Anaesthetist, Both of The Hospital for Sick Children, Great Ormond Street, London, UK.

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Fill in the application form on the other side of this page.

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to

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......................19

To the Honorary Secretary,
Association of Anaesthetists of Great Britain and Ireland

I (full name) .... offer my name as a candidate

BLOCK LETTERS

for (a) ORDINARY MEMBERSHIP (b) OVERSEAS MEMBERSHIP (c) ASSOCIATE MEMBERSHIP (d) JUNIOR MEMBERSHIP of the Association (*please delete categories not applicable*)*

I hold the following appointment(s) as an anaesthetist (*please state grade if in the National Health Service, and indicate the approximate proportion of time spent in the practice of anaesthesia*):

....

....

....

Qualifications (with dates)...

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....

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(NAME IN BLOCK LETTERS)
Address..
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* See the reverse of this page for details of membership categories.
† One sponsor must be an Ordinary Member of the Association.

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Manuscripts will be reviewed for possible publication on the understanding that they are being submitted to one journal at a time and have not been published, simultaneously submitted, or already accepted for publication elsewhere. This does not preclude consideration of a manuscript that has been rejected by another journal or of a complete report that follows publication of preliminary findings elsewhere, usually in the form of an abstract. Investigations performed on man must conform to appropriate ethical standards including voluntary, informed consent and acceptance by an ethical committee. Articles accepted become copyright of *Anaesthesia*.

Contributors are requested to submit two copies of manuscripts. They are also advised to retain a third copy as the Editors cannot accept responsibility for the loss of manuscripts in the post. The covering letter should be signed personally by all the authors and careful consideration should be given to the decision to include more than five authors. Articles should be forwarded to:

Dr J. N. Lunn, Editor of ***Anaesthesia****, Department of Anaesthetics, University Hospital of Wales, Heath Park, Cardiff CF4 4XW, UK.*

PREPARATION OF MANUSCRIPTS

Articles for *Anaesthesia* should be prepared in accordance with *Uniform requirements for manuscripts submitted to biomedical journals* (*British Medical Journal* 1979; **1:** 532–5) except that the titles of journals in the reference section should be given in full (see below). A reprint of these requirements of which this notice is a summary, can be obtained from the *British Medical Journal* price 50 pence (UK).

Type manuscripts on white bond paper, 20.3 × 26.7 cm or 21.6 × 27.9 cm (8 × 10½ in. or 8½ × 11 in.) or ISO A4 (212 × 297 mm) with margins of at least 2.5 cm (1 in.). Use double, and preferably triple, spacing throughout, including the references. Please do not use a dot matrix printer, particularly one with poor quality descenders or ascenders. Unseparated, fan-folded manuscripts may be returned to the author. *The manuscript* should consist of the following sections in this order each beginning on a new page: *title page, summary* and *key words, text, acknowledgments, references, individual tables*, and *legends for figures*.

Number pages consecutively, beginning with the title page.

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The name of the author and the address to which proofs and other correspondence are to be addressed should appear in the top left-hand corner of the sheet.

The main title should be restricted to five words if this is possible. It should be typed in capitals across the centre of the title page.

A subsidiary title of not more than 12 words may be supplied if this is considered to be necessary. This should be typed in lower case immediately beneath the main title.

The names of the authors should be typed IN CAPITALS across the title page immediately beneath the titles without degrees or designations. Initials should precede the surname. If there is more than one author the word 'AND' should be placed before the name of the last author.

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Start a new sheet

The second page should carry a summary of not more than 150 words. The summary should state the purpose of the study or investigation, basic procedures, main findings and their statistical significance, and the principal conclusions.

Do not use abbreviations except for units of measurement (e.g. mg, cm, etc.).

Key (indexing) words. Below the abstract, provide and identify as such, three to 10 key words or short phrases that will assist indexers. Use terms from the Medical Subject Headings list from *Index Medicus*. The Editor may modify these at proof stage to conform with agreed practice of certain other anaesthetic journals in the English language.

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THE TEXT

Start a new sheet

The text of observational and experimental articles, case reports, etc. is usually divided into sections with the headings *Introduction, Methods, Results* and *Discussion*. Long articles will need subheadings within some sections to clarify their content.

Letters for the correspondence pages should be double spaced and prepared in accordance with the format in a recent copy of *Anaesthesia*.

Headings: three steps of heading may be used in typescripts:

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Acknowledge those who have made substantive contributions to the study or the preparation of the manuscript. Authors are responsible for obtaining written permission for publication of reproduced figures and tables from authors and publishers and from everyone acknowledged by name because of copyright conventions and because readers may infer their endorsement of the data and conclusions.

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Number references consecutively in the order in which they are first mentioned in the text. Identify references in text, tables and legends by arabic numerals. References cited only in tables or in legends to figures should be numbered in accordance with a sequence established by the first identification in the text of the particular table or illustration. Use double or treble spaced typing.

Use the form of reference adopted by the US National Library of Medicine and used in *Index Medicus*. Use the style of the examples cited at the end of this section.

The titles of journals should be given in full.

Avoid using abstracts as references except those published in a recognised journal. 'Unpublished observations' and 'personal communications' may not be used as references, although references to written, not verbal, communications may be inserted (in parentheses) in the text. Include among the references manuscripts accepted but not yet published; designate the journal followed by (*in press*) in parentheses. Information from manuscripts submitted but not yet accepted should be cited in the text as (unpublished observations) in parenthese.

The references must be verified by the author(s) against the original documents.

(*continued overleaf*)

Examples of correct form of references
Note: first and last pages in all references.

JOURNAL
Standard journal article—(List all authors)
SOTER NA, WASSERMAN SI, AUSTEN KF. Cold urticaria: release into the circulation of histamine and eosinophil chemotactic factor of anaphylaxis during cold challenge. *New England Journal of Medicine* 1976; **294:** 687–90.

Corporate author
The Committee on Enzymes of the Scandinavian Society for Clinical Chemistry and Clinical Physiology. Recommended method for the determination of gamma-glutamyltransferase in blood. *Scandinavian Journal of Clinical Laboratory Investigation* 1976; **36:** 119–25.
Anonymous. Epidemiology for primary health care. *International Journal of Epidemiology* 1976; **5:** 224–5.

BOOKS AND OTHER MONOGRAPHS
Personal author(s)
OSLER AG. *Complement: mechanisms and functions*. New York: Prentice-Hall, 1976.

Corporate authors
American Medical Association Department of Drugs. AMA drug evaluations, 3rd edn. New York: Publishing Sciences Group, 1977.

Editor, compiler, chairman as author
RHODES AJ, VAN ROOVEN CE, *comps. Textbook of virology: for students and practitioners of medicine and other health sciences*, 5th edn. Baltimore: The Williams & Wilkins Co., 1968.

Chapter in book
WEINSTEIN L, SWARTZ MN. Pathogenic properties of invading micro-organisms. In: SODEMAN WA Jr, SODEMAN WA, eds. *Pathologic physiology: mechanisms of disease*. Philadelphia: W.B. Saunders, 1974: 457–72.

Agency publication
National Center for Health Statistics. Acute conditions: incidence and associated disability, United States, July 1968—June 1969. Rockville, MD: National Center for Health Statistics, 1972. (*Vital and health statistics, Series* **10:** Data from the National Health Survey, No. 69) [DHEW publication No. (HSM) 72–1036].

OTHER ARTICLES
Newspaper article
SHAFFER RA. Advances in chemistry are starting to unlock mysteries of the brain: discoveries could help to cure alcoholism and insomnia, explain mental illness. How the messengers work. *Wall Street Journal* 1977 Aug 12: 1(col 1), 10(col 1).

Magazine article
ROUECHE B. Annals of medicine: the Santa Claus culture. *The New Yorker* 1971 Sept 4: 66–81.

TABLES

Do not include tables in the text. Start a new sheet for each table and space the material adequately. The author(s) name(s) should appear in the top right-hand corner.
Indicate the approximate position of each table in relation to the subject matter of the text in the left-hand margin of the appropriate page on the manuscript. Do not submit tables as photographs. Number tables consecutively with arabic numerals. Supply a brief title for each. Give each column a short or abbreviated heading. Place explanatory matter in footnotes. Explain in footnotes all non-standard abbreviations that are used in each table. For footnotes, use the following symbols in this sequence: *, †, ‡, §, , ¶, **, ††, etc. Identify statistical measures of variations such as SD and SEM. *Legends for tables* should appear on the face of the table.

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Each figure should be separate. Do not include figures in the text but collect together in an envelope or folder.
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All sources of identification of patients must be removed.

LEGENDS FOR FIGURES

Start a new sheet
Type legends for illustrations double spaced with arabic numerals corresponding to the illustrations. When symbols, arrows, numbers or letters are used to identify parts of the illustrations, identify and explain each one clearly in the legend.

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Statistics and measurements should be given in figures except that numerals one to nine should be in words if not followed by a measurement symbol (e.g. 'two patients' but '2.0 mg'). The *Système International* (SI) will usually be used except that vascular pressures will be recorded in mmHg and cmH_2O. Imperial measurements will not be used except in an historic context. The 24 hour clock will be used.

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The statistical tests used in the report should be stated clearly. Results should include 95% confidence limits for the main findings and probability estimates.

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